The American

GAS LIGHT JOURNAL.

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(ILLUSTRATED.)

DEVOTED TO THE INTERESTS OF

ILLUMINATION, HEATING, MECHANICAL, CHEMICAL

AND

GENERAL SCIENCE.

VOLUME LXXX.

(FORTY-SIXTH YEAR.)

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Items ... 1

Entrance ... 2

Overture ... 2

Song: "Hail, Columbia" ... 3

Solo: "Star-Spangled Banner" ... 4

Address ... 5

Prayer ... 6

Anthem ... 7

Song: "America" ... 8

Benediction ... 9

Closing Voluntary ... 9

Exit ... 10

Boys' Entrance ... 10

Boys' Overture ... 10

Boys' Song: "Hail, Columbia" ... 11

Boys' Solo: "Star-Spangled Banner" ... 12

Boys' Address ... 13

Boys' Prayer ... 14

Boys' Anthem ... 15

Boys' Song: "America" ... 16

Boys' Benediction ... 17

Boys' Closing Voluntary ... 17

Boys' Exit ... 18

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REDMAN & KENNY, N.Y.

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The Public Lighting Tables of the American Meter Company will be found in the page advertisement of that Company.

CONTENTS.

An Asterisk (*) denotes an illustrated article.

OFFICIAL NOTICE—
- Novelty Advertising Department, Ohio Gas Light Association..... 1
- Wrinkle Depaatment, Ohio Gas Light Association..... 1
- Eleventh Annual Meeting. Michigan Gas Association..... 1

EDITORIALS—
- Briefly Told..... 2
  A Correction—Notes.

CORRESPONDENCE—
- Something More About Gas Arcs and Their Utility 2
- Some Speculations on Mantle Burners, by Dr. W. H. Birchmore.... 2
- *Notes on Gaseous Firing, by Mr. J. F. Smith..... 4
- Heating and Ventilating of Foundries and Machine Shops, by Mr. W. H. Carrier..... 9
- Production of Natural Gas in 1902..... 10
- American Central Electric Station Statistics—No. IV.—Concluded from Vol. LXXIX., p. 1011 11

ITEMS OF INTEREST FROM VARIOUS LOCALITIES..... 12
Happy Ending of the Troubles of the Isbell-Porter Company—How Mr. Goulding Fares at Natick, Mass.—Annual Meeting, Rochester, N. H.—No Case, Windsor, Can.—Dividends, Newtown and Flushing (N. Y.) Gas Company—The Hartford (Conn.) Gas Securities Company—A Cleverly Arranged Consumers' Meter Record System—Report, Buffalo (N. Y.) Gas Company—Franchise Extended, Jeffersonville, Ind.—Change in Ownership, Stoughton, Mass.—Mr. A. G. Briggs in Charge at Merced Falls, Cal.—Something from Quincy, Ills.—And Other Items.

- The Market for Gas Securities..... 14

[OFFICIAL NOTICE.]

Novelty Advertising Department, Ohio Gas Light Association.

OHIO GAS LIGHT ASSOCIATION,
OFFICE OF SECRETARY, DELAWARE, O.,
December 12, 1903.

The Editor of the Novelty Advertising Department, Mr. B. W. Perkins, of South Bend, Ind., desires to announce that his department is now open for contributions to be presented at the Twentieth Annual Meeting, which will be held in Cleveland, March 16th, 17th and 18th.

This department is one of the most attractive features of the convention Its success, however, depends largely upon the active co-operation of the members. It is, therefore, earnestly hoped that the fraternity will not be backward in sending advertising schemes to Mr. Perkins.

T. C. JONES, Secretary.

[OFFICIAL NOTICE.]

Wrinkle Department, Ohio Gas Light Association.

OHIO GAS LIGHT ASSOCIATION,
OFFICE OF THE SECRETARY, DELAWARE, O.,
December 28, 1903.

The Editor of the Wrinkle Department, Mr. E. E. Eysenbach, St. Paul Gas Light Company, St. Paul, Minn., earnestly solicits the co-operation of the fraternity for contributions to be presented at the Twentieth Annual Meeting of the Association, which is to be held at the Hollenden Hotel, Cleveland, March 16th, 17th and 18th, 1904.

Editor Eysenbach will be pleased to receive contributions not later than February 15th. T. C. JONES, Secretary.

[NOTICE.]

Eleventh Annual Meeting, Michigan Gas Association.

MICHIGAN GAS ASSOCIATION,
OFFICE OF THE SECRETARY,
ANN ARBOR, MICH., Jan. 1, 1904.

The Eleventh Annual Meeting of the Michigan Gas Association will be held in Saginaw, Wednesday and Thursday, the 17th and 18th of February, 1904. The headquarters of the Association will be at the Hotel Vincent. The meeting is to be held in the parlors of the Saginaw Club. The following papers will be read:

"A Few Notes on Ammonia," by Mr. F. E. Sheriff, Battle Creek, Mich.

"The Laying of High and Low Pressure River Gas Lines," by Mr. H. C. Morris, Bay City, Mich.

"The Laying of Mains and Services and Recording of Same," by Mr. John Hellen, Grand Rapids, Mich.

"Care of Benches and Results Therefrom," by Mr. Thos. J. Whalen, Jackson, Mich.

"Advertising: As Advantageous to the Gas Business," by Mr. A. P. Ewing, Detroit, Mich.

"A Report of Progress on the Study of Naphthaline," by Mr. Samuel Ball, University of Michigan, Michigan Gas Association Scholarship.

In addition to these papers, the Question Box will be made the feature of one session. Replies to all questions received are now in preparation.

A beefsteak supper will be served the members at the East Saginaw Club, on the evening of February 17th, by the Saginaw Gas Company.

Rates at the Hotel Vincent have been secured as follows:

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JAN 6 1904
SMITHSONIAN DEPOSIT.

Room without bath, for one person.....	$2.50	per day.
" " two persons.....	5.00	"
Room with bath, for one person.....	3.00	"
" " two persons.....	6.00	"

The Bancroft House is an equally good hotel, where similar rates can be obtained. Those desiring good accommodations should write in advance.

This meeting promises to be the best in the history of the Association, and every member is urged to be present. Members of other Associations, and gas fraternity in general, are cordially invited to meet with us.

H. W. DOUGLAS, Secretary.

BRIEFLY TOLD.

A CORRECTION.—Zealousness for purity and accuracy is to be commended, and so we acknowledge our indebtedness on such scores to Mr. A. E. Forstall, Secretary of the American Gas Light Association, who, in a communication to us dated December 30th, writes—partially: "I have just read the installment of the 'Abstract Proceedings, Thirty-first Annual Meeting, American Gas Light Association,' in the issue of the JOURNAL, for December 28th, and notice that you have credited to Prof. Mavor, the written contribution prepared by Mr. Clark for the discussion on the paper, 'Some Features of Municipal Ownership,' and have assigned to Mr. Clark the authorship of the communication from Prof. Mavor." We are sorry that the thunder of either gentleman was sounded by the other, through our inadvertence and the task it was to keep straight anything in the line of "copy" from William street that was needed for the speedy completion of the "Year Book," which evidently will not see the light until the year after. However, our apologies here to Mr. Clark and to Prof. Mavor, and our thanks to the friendliness that prompted Secretary Forstall's corrective lines.

NOTES——

MR. L. H. FISCHER, of Danville, Ills., has been appointed Manager of the gas, heating and street railway plants under control of the Decatur (Ills.) syndicate. He succeeds Mr. W. A. Bixby, who goes to Quincy, Ills., there to assume the management of the Quincy Gas and Electric Company.

SOME of the residents of Chelsea, Mass., are agitating the subject of the control of the local gas and electric lighting plants on municipal account.

THE handsome, complete new electric lighting plant of the Pawtucket (R. I.) Gas and Electric Company is in satisfactory operation.

Correspondence

[The JOURNAL is not responsible for the opinions expressed by correspondents.]

Something More About Gas Arcs and Their Utility.

GENERAL GAS LIGHT COMPANY,
KALAMAZOO, MICH., Dec. 24, 1903.

To the Editors AMERICAN GAS LIGHT JOURNAL: It seems probable that the section of President Miller's very able address, in which he refers to the so-called "Gas Arcs," was the one to which he gave the least thought; and, judging from criticisms heard at the convention and appearing since, his conclusions are not generally acceptable to gas men. The name given this lamp is descriptive and suggestive of its appearance and its use, not an unusual thing to do. The fact is the gas arc lamp is the best medium for obtaining light from gas known to-day, from either the standpoint of the consumer or the gas company. Whatever theoretical loss there may be in the light distribution is very much more than overcome by the great efficiency of the burners and the better reflector service; a 4-light lamp giving more light and a better distribution of it than any arrangement of six individual lights on a chandelier.

The cost of maintenance is lessened at least 75 per cent., and the objectionable features, such as broken chimneys, carbonized mantles, etc., are entirely eliminated. Furthermore, the convenience of lighting and extinguishing alone would, in most places, displace individual lights in lighting large areas.

The "Gas Arc" may not be a "thing of beauty," its appearance having been sacrificed to some extent to efficiency and durability, yet most people seem to think that, in a contest with an old-fashioned, long-armed chandelier or an electric arc it is a pretty good looking affair.

The old arguments used in our attempts to resist the electric arc are pretty firmly fixed in the minds of some of us, but as they did not prevail we think it is probably best that they be forgotten.

Very respectfully, GENERAL GAS LIGHT COMPANY.

[Prepared for the JOURNAL.]

Some Sp[illegible]lations on Mantle Burners.

By W. H. BIRCHMORE.

Every few days a per[illegible] willing to listen may hear some one of that multitude whose life vo[illegible]on is to complain expressing in virile English his wonder that some one does not make a perfect gas light. It never seems to enter the minds of these people, assuming that they have attributes so totally useless as minds, which in many cases is at least doubtful, to reflect that the modern method of illumination is not yet 20 years old. They seem unconscious of the fact that the Chicago "World's Fair" nearly agreed in data with the introduction of the Auer von Welsbach mantle to the notice of the gas using multitudes. It is so, however, and from the public viewpoint the marvel is that so much has been done, not that there is something more to do. There is indeed much to do, but not along the lines which the growling user seems to think and believe. The user complains that his mantles break and that they blacken, that his chimneys go to pieces, that they gradually cease to be transparent, and he finds time too to tell of other causes of vexation and complaint, but always with the reservation that none of these mischances are found in the experience of his neighbors. Such men actually flatter themselves that their names are in "Destiny's" visiting list.

That the mantle user should complain of this series of trials and tribulations is but natural. He knows of them, and he is able to appreciate to some extent their opportunity for making a nuisance of themselves. That their opportunity is his own fault does not in any way hinder his habitual complaining. He complains because he finds himself in situation for recognizing these causes for grumbling, but he never complains in regard to the hundred shortcomings of his gas fixtures, real faults about which he knows nothing at all.

But to complain of that which merits complaint, which deserves and justifies something more than simple grumbling, belongs to the men of the gas works and to those whom circumstances have made their helpers and their aides. If the men who are the real sufferers from the defects in the appliances now in use for converting heat into light (the managers of the gas works and the inspectors of meters and customers' fixtures) were as voluble as the customers, the sky would be blue indeed. There is no sufficient excuse for this state of things. It cannot be said that the "inventor class" have not had the opportunity to see the faults of the product and to remedy the same, for so ardent is the pursuit after a really satisfactory burner that the manufacturers seem to be ready and willing to try anything which shows any sort of a promise of successfully meeting its existing faults.

Standing on their respective pegs in my book case are burners, or parts of burners, representing past and present forms, commercial and non-commercial and experimental, all intended for use with the mantle and representing a few of the developments since 1890. Some are fragments, pieces which are modified under the impression that the cap, or the gallery, or the air supply shutter was the thing needing change to make a perfect burner, yet in all of them is seen that tendency to imitation which binds to the past the man who seeks to improve by modification, yet who knows not why he modifies nor where modification is needed. Sixteen of these are modifications of the primary form of air shutter (below the inlet for air) in the Bunsen tube, yet in not one of the 16 is there a hint that the inventors (may Heaven be merciful to them) had any idea what such an important factor as the air supply should be. Thirty-eight tubes have some means of modifying the gas supply. Twelve have some adaptation of the injector theory of Körting, yet if the parts are measured it is plain that the dimensions of the cones, the pitch and the places were selected to satisfy the fancy or imagination of the makers and not the pressure, specific gravity and speed of issue of the gas. Not one of all the would-be "future type of burner" models meets and satisfies the conditions; although one, being adjustable, comes nearer than the rest, and this one is a model burner, totally impossible in other ways.

Another interesting fact, patent in all the patterns, is the disregard of experience in the setting of the two cones which form so important a part in every high power burner. Speaking at large every high duty burner is, and from the nature of the case must be, composed of two cones, truncate as to the apices, and joined by a portion of a cylindrical tube, which tube is joined at one end to one cone and at the other end to the other cone. It chanced that in one of the rather less unsuccessful than usual burners made a few years since this connecting tube extended (by accident apparently) beyond the apex and about one-third into the upper cone. The mistake was corrected in the next issue

of burners, but a number of "improved burners" came out and in every one this mistake was copied, a perfect demonstration of the originality of some inventions. While unlike in some trivial detail all the modifications were alike in this point, plainly showing that the inventors could not distinguish between an unimportant detail and an important one, yet had the mathematics of these burner designs been worked out they would certainly have made clear the true position of these cones.

There is another important detail which none of the inventors seems to find time to adjust, the aperture by which the gas enters the tube. In all forms it acts as an appliance for limiting the amount of gas supplied to the burner. This limiting orifice has a different function in the various forms of burners. In one form (the one used with the chimney) the air is drawn in to feed the flame by the chimney's active suction, and the gas entering the mixing chamber, under the influence of its own elasticity, rapidly diffuses. For such a burner the best arrangement is that suggested by Bunsen for the burner which bears his name, in which burner the heated tube caused the influx of air, and the ascension power of the gas diluted air gave the first upward impulse. In this form of burner the best method of construction, at least with reference to accurate functional success, seems to be a single hole in a very thin plate of metal. Copper plate $\frac{1}{2}$-hundredth of an inch thick does very well, if the hole is not less than $\frac{4}{100}$ of an inch in diameter, but if less than this thin sheet steel $\frac{1}{2}$-hundreth has heen recommended. When thin plates like these are used no further compensation for the change from gas of specific gravity 0.34 to that of specific gravity 0.45 (the limits in practice) need be made than that which elasticity furnishes. When, however, the plate is so thick that the hole becemes a tube a number of diameters long, it will seriously interfere with the discharge unless correctly shaped.

When the impulse of the gas is utilized on Körting's principle it is important, while limiting the amount of gas, not to lessen the velocity and force of the discharge. In this case a carefully designed and accurately executed nozzle must be made, not a hole as in one well-known burner, $\frac{1}{32}$-inch in diameter and $\frac{6}{32}$ long. In this case the tube not only limits the amount of the discharge, but reduces the pressure beyond any useful limit; indeed, the aspirating power is in effect lost. Few burner builders, meaning those who invent new burners, seem to understand, and few manufacturers seem to regard, the distinction in underlying principles between the injector and the draft burners, and yet these two classes are really quite unlike. They are machines belonging in different categories.

Curiously enough almost none of the inventor tribe seem to understand the function of the chimney, its relation to the mechanics of the flame, or its reason for existence; others seem to think that an odd shape or a change in its length will be an advantage, but why or what the advantage they never can explain. Not long since a man was kind enough to show me a metal-topped chimney which he said was "twice as good as one all glass," but the reasons given were not convincing. None of the inventors whom I have met are fully informed as to the difference in the function of the chimney, when an injector burner is used and when an ordinary or draft burner is employed.

All this confusion is due simply to the lack of insight into the problem's fundamental conditions, and the manufacturers having already burners which "do very well" are in every way justified in refusing to consider as business propositions any new burner which is presented to them until it has not only shown itself better than the present ones, but approximately ideal. If I am gifted with such a number of sample failures how many is it rational to infer the manufacturers receive, burners in almost every case made in quest of perfection, yet by men who do not seem able to tell another for what they seek.

The problem has certain fixed facts, physical data; the gas with an average specific gravity not far from 0.4, under a definite pressure, the number of B.T.U. is also not particularly variable. The amount of air required to burn the gas is well known, and the products of combustion can be calculated. These are all the data required for working out the problem. Why, then, is it that some inventor does not go to work at the task in a serious way? Is it because of the success of the present burner? Not likely; the present burner has not succeeded. It is far more likely that the refusal to act is due to the notion that the study of the mathematics is all right for the amateur, but beneath the notice of the practical man. It is my own belief none the less that before long someone will go at the problem as the need is and win.

As has been said before, the gas exit to the burner is best made with a simple opening, as this is less likely to produce complex vortices than a number of openings. Some time since there was a burner purchased everywhere in which the gas exit consisted of three small holes in a brass diaphragm. These holes were punched and should have been the same size, but were not. Removing this diaphragm and putting in place of it a thin piece of steel of a thickness equal to one-fourth that of the brass one cemented to a ring of copper about the same thickness as the original plate, and having made a hole in the center of the chosen diameter, air was passed, and the measured result coincided with them.

It was also evident that before the gas was lighted the ascension power of the gas was different from that of the theory by less than any assignable proportion; and when the chimney was put on the amount of air drawn in showed a reduction in pressure equal to a column of air of the same height of a temperature beyond the safe range of a mercury thermometer, and this draft was increasing with the length of the chimney almost exactly. But when the mantle was in place the air passed was twice the useful volume, and to have satisfied the air supply required more gas than the heating of the mantle. The cutting down of this air supply two-thirds and the gas nearly one-half did lessen the light-giving power of the mantle burner combination. Correct adjustment, therefore, has economic value.

In the injector burners the correct shaping of the nozzle increases the efficiency in two ways, but the most important change in the efficiency is the relative reduction in the amount of unburned gas. It is doing battle with a windmill to try to explain this to inventors; but to say to the gas man, "Do not be in a hurry to change from the burners whose faults you know, to new ones whose faults you will have to learn," is fully justified.

Speaking from my own point of view, it seems peculiar that someone of the highly trained mathematicians from the technical schools does not sit down with the needed "plant" and work out, once and for all, the series of equations representing all the facts in such way that a burner can be made which in all respects conforms to the demands of the laws of gases, both before and after the combustion has taken place. Such a labor would be well remunerated by the enormous trade which would come to him who should develop this lucubration into brass.

If the gas companies are to continue to protect their business by installation of burners and mantles, by renewals and the like, they certainly are justified in insisting on properly designed and proportioned burners; but they are not justified in changing from those of this present until they have had a demonstration, not that the new burner offered to them is a trifle better and consumes a few cubic inches less gas per candle power hour, but that it is the very best burner that can be made for burning a gas, so heavily carburetted as is most illuminating gas, under a pressure so unsatisfactory as this of the hour. It is well to avoid Scylla but there is not call for going to ruin on Charybdis.

Mathematics and physics cannot and will not enable a man without mechanical common sense to make even a passable burner, but they will inform the man of mechanical common sense in regard to certain laws which he cannot violate and then go unpunished. When someone troubles himself to calculate the parts of a new gas burner, so that the proportions of these parts conform to the laws which govern the physics of gases, he will produce a burner so much better than any yet made that recognition will be instantaneous; and since the more perfect coincidence will bring the more perfect success, it is safe to say that many will follow his path, agreeing in the bold outline, but differing in details which at present our mathematics will not cover. The burners of the past have been the experiments by which the mathematical laws have become subjects of investigation; the next era will, or should be, marked by the application of what we have learned.

To summarize our information, at present mathematics can give shape and dimensions of the opening by which the gas enters the burner, the shape and dimensions of the cones, both at the inlet and exit openings. Somewhat less certainly we can determine the proper relation of the two cones at their junction, but the relations of the chimney and the primary air supply are at this present impossible; but mathematics can and does tell us that the cylinder is not the best possible shape for a gas burner chimney when the mantle is in use.

The figures which science can give are freely given to everyone of us, but to combine these data to the forming of a perfect burner reqnires not mathematical information only, but mechanical genius also, and the man who makes the first successful model of that for which we are all longing, a quasi perfect burner for the mantle light, will be one who, having mechanical genius, but not an ignorant disdain for mathematics and mathematical physics, will combine the two, and will produce in brass the physical equivalent for the mathematical solution made in the library, and the diagrams of the expression on paper of the mathematician's lucubrations.

For such an one the future has a laurel wreath, and the gratitude of mankind. It may be that he is even now among us, unknown as yet to fame; but hopeful, yes, confident of his future. Will we recognize him when he knocks? Who shall say?

Notes on Gaseous Firing.

[A paper read by Mr. J. F. Smith, of Halifax, England, before the Yorkshire Junior Gas Association.]

Gaseous fuel was first proposed by Lampadius in 1801; but it was not until 30 years afterwards that he brought his proposal into practice.

Aubertot, in 1812, was granted a patent for the application to metallurgical purposes of the combustible gases escaping from an iron furnace; and in the year 1830, attempts were made at the lead works at Halsbrücke, near Freiberg, to employ the flame of coal gas in cupelling the silver lead. But neither of these attempts at introducing gaseous combustibles as fuel was followed up until the subject was carefully investigated by Faber in 1837, at an iron works in Würtenberg, the results of which led to the general adoption of the waste gases from iron furnaces as fuel, and the production of gas specially for the purpose.

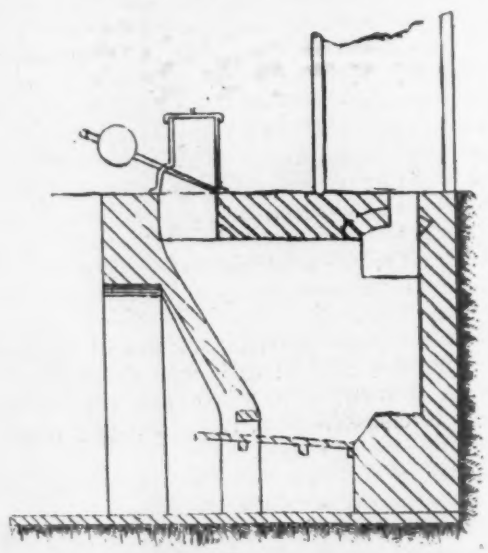
For conducting the waste gases from the iron furnace, Faber made in the side of the furnace several apertures which were connected to a flue, leading from which was an iron pipe for conveying the gas to the place of consumption. The flow of gas was regulated by a damper fixed into the pipe.

Bischof designed a generator without blast that was used at Magdesprung, in the Hartz. The central part or body of the furnace was cylindrical, and was about 5 feet in diameter and 5½ feet high. The upper and lower parts were conical, the upper being about 4½ feet and the lower about 2 feet high. At the bottom of this was a conical grate, below which was an ashpit that could be closed by an iron plate. The door of the furnace could be closed by a sheet of iron. The gases escaped from the upper part of the furnace, which was covered by sheets of iron and sand, so as to retain as much heat as possible. In this flue was fixed a damper for controlling the escape of the gases. The throat of the furnace was separated from the body by means of an iron damper. The space above this was sufficiently large to hold a charge of the solid combustible matter with which the generator was supplied at intervals; and by withdrawing the damper this could be dropped into the furnace without opening the top lid. The air was supplied to the generator through 3 apertures (2 inches in diameter) in the iron plate cover of the ashpit. The production of gas was controlled by means of the damper and these 3 apertures. The progress of combustion could be watched through three square apertures or sight holes in the side of the furnace, which could be closed by means of bricks.

About 1841, Ebelmen designed and erected a generator at Audincourt, which was intended to be worked with a blast of air. This furnace was slightly different in shape from any of the previous ones. In its proportions, it resembled a small iron furnace—being about 10 feet high; the widest parts being about 3 feet 6 inches, the narrowest part (which was about the hearth) being only about 10 inches, and the throat of the furnace about 13 inches in diameter. A cast iron pipe was placed down into the furnace, so that the end would project about 4½ feet into the body of the furnace. This pipe was kept constantly filled with the fuel. A lid was only necessary when the fuel was large, as the small fuel was sufficient to prevent the passage of the free gas from the furnace. Round the pipe the gases could collect, and then pass along a pipe fixed into the side and near the top of the furnace, to the place where they were required. A much more abundant supply of gases could be got from this furnace than from any of the others. The blast used was considerable, so that the gases could be used below the level of the furnace. It was a drawback in the previous constructions, that the hearth where the gases were to be consumed had to be on a level with the exit tube of the furnace; so that in many cases the generator had to be sunk below the surface of the ground.

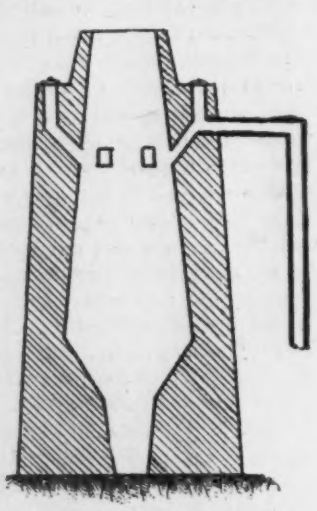
Regenerators were first used by Dr. Stirling, of Dundee, in 1817, in connection with an air engine which he patented in that year. The regenerator consisted of strips of glass or metal, brought closely together. The principle of its action was first a lowering of the heat of a fluid by giving up its heat to the regenerator.

The first application of regenerators to furnaces was made in 1856 by Frederic Siemens. In this arrangement solid fuel was used, which was burnt intermittently on two separate hearths—having a furnace in the center of them, the air passing between. The air in the furnace passed first through the regenerator, and then to the burning fuel. The waste products of combustion, after heating the furnace, gave up their remaining heat to the second regenerator, and then passed to the chimney. The current was reversed by means of valves specially constructed for the purpose; and the air was made to pass in the opposite direction—the second fireplace being at the same time supplied with fuel.

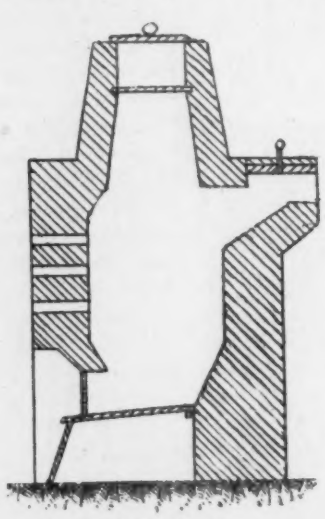


The Siemens' Generator.

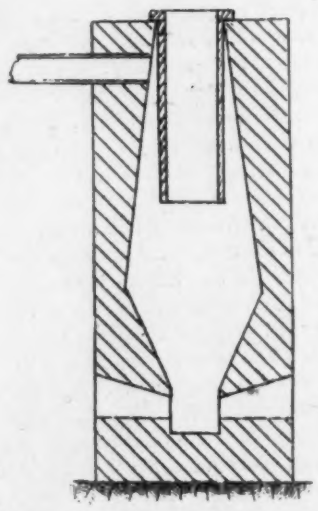
During the following year improvements were made to this furnace, the chief being a plan of heating a single chamber continuously by means of one fireplace, in combination with the alternate reversals of the currents through the generators, without reversing the direction of the flame. In this patent there seems to be the first idea of a separate producer and regenerator. This was developed by Sir William Siemens, who brought out in 1861 a regenerative gas furnace with a separate producer and a gas and air regenerator which is now used in metallurgy. A special application of this furnace was introduced in 1866 for melting steel in pots; and in 1868 horizontal regenerators were employed. The gas generator was uppermost; and a small chamber for air and gas, which prevented combustion therein, directed the flame in a jet through



Faber's Furnace.



Bischof's Generator.

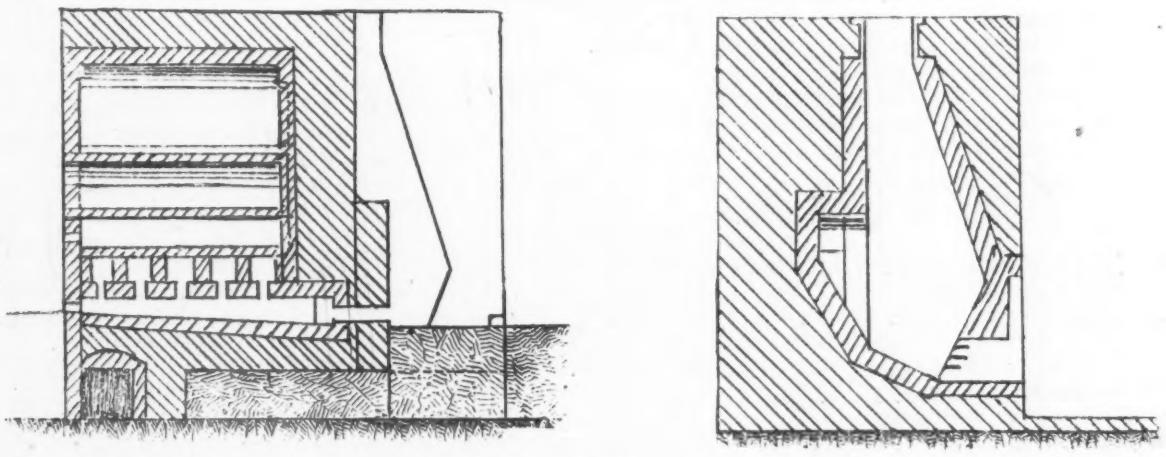


Ebelmen's Furnace.

a tapering aperture across the bed. This arrangement also afforded facilities for the cleaning out of the flues; for which purpose manholes were placed in the regenerators. The application of the gas furnace to annealing furnaces and steam boilers was also described by him at this time.

In 1870, a new form of producer was made by him, which was introduced into the glass industry—one of the first industries, outside metallurgy, to take up regenerator furnaces.

The gas producers first introduced into gas works for heating retorts were outside generators, some with the reversing valves and some without. The only one of these that will be referred to was built in 1873 by Messrs. Muller and Co., and experimented with by M. Fichet at the



Fichet's Setting and Generator.

Montreuil Gas Works. This setting had the gas producer built at the back, and was of the open grate pattern. The producer made the gases for two beds of seven retorts. The air was admitted in front, under the retorts, after it had been made to pass through channels in the brickwork. The proportions of the gas and air were regulated by means of dampers; and the temperature of the furnace was regulated by means of the chimney damper. The results obtained with this were equal to the coke produced by 17½ pounds of coal per 100 pounds of coal carbonized, against the 30 to 35 per cent. in the direct fired setting at those works.

One of the first, if not the first, setting with inside generator and regenerators that worked successfully, was at the Denton New Gas Works (Cheshire), in 1883. Before this, the generators or producers were outside.

The regenerator furnace is now so well known that it will not be necessary to describe the many settings that have been brought forward by both English and Continental engineers, and which are known by their names.

Thermal Chemistry.—The principle of gaseous firing is based upon the well known reaction that, when a solid fuel is burnt with insufficient oxygen or air, a combustible gas is formed, which is represented (in the case of carbon) by the formula: $C + O = CO$. This gas can be burnt to carbonic acid in the required place by the combination with a further supply of air—thus: $CO + O = CO_2$.

The theory of the formation of the producer gas is that the incandescent carbon in the presence of air is first converted into carbonic acid, and that this gas, on passing through a further portion of the incandescent carbon, is converted, by taking up a further atom of carbon, into carbonic oxide, which may be represented as follows: $CO_2 + C = 2CO$. This theory is supported by analyses of samples of gases taken from different depths of the fuel beds. The following results, taken from Boelmen's analysis, show this very clearly:

	Height above Air Inlet.		
Constituent.....	8 inches	1 foot	2 feet
Carbonic acid.....	8.11	5.87	0.16

It is evident from these figures that the production of carbonic acid is done in a very thin layer of the fuel, and is probably a surface reaction. The equations usually given in text books for the calculation of the heating value of fuels are not accurate; so that the values obtained by their use vary very considerably from those obtained by direct experiment. The sources of error are chiefly as follows:

1. Uncertainty of the heating power of carbon when in combination, since the different varieties of the element give different figures.

2. The heating power of hydrogen is determined for the free gas. In solid fuels, the hydrogen is not gaseous, but solid; and in that condition its heating value must be different.

3. Compound bodies never give the same amount of heat on combustion as the elements of which they are composed would do in a free state; the amount of heat evolved by the combustion of the compound being usually less (though sometimes it is more) than that given by the free elements, according as the compound itself was formed with the evolution or absorption of heat.

4. Sulphur is not in a free state as given in the equations, but is in combination as sulphide and sulphate, and would require different amounts of heat to be added to them before the sulphur would be liberated for combustion.

5. The ash is not taken into the calculation, though there are always thermal reactions occurring in it during the burning of the fuel, or in the production of a combustible gas.

It will be seen that it is anything but a simple matter to calculate the heating power of a solid fuel, such as coke; for this requires not only a very complete analysis, but a complete knowledge of the state of combination in which the substances exist in that fuel.

These facts stand in the way of a complete understanding of all the changes that go on in a gas producer; so that, in order to get a general idea, it is best to suppose that we are dealing with pure carbon. It has already been stated that gaseous firing depends on the production of carbonic oxide in the furnace and afterwards burning this with the proper proportion of air. In the formation of the carbonic oxide there will be evolved 4,350 B.T.U. for every pound of carbon burnt to this compound; so, that, if we take our formula as representing pounds of the substances represented in that equation, we should get—

$$C + O = CO$$
$$12 + 16 = 28$$

in which there would be $12 \times 4{,}350$ B.T.U. = 52,200 B.T.U. given out in the formation of 28 pounds of carbonic oxide; or, taking the theory that carbonic acid is first formed and then reduced to carbonic oxide, the reactions would be—

$$C + O_2 = CO_2$$
$$12 + 32 = 44$$

in which the heat units would be $12 \times 14{,}500 = 174{,}000$ B.T.U., which is the heat of formation of 44 pounds of carbonic acid, which on reduction to carbonic oxide would be—

$$CO_2 + C = 2CO$$
$$44 + 12 = 56$$
$$174{,}000 \text{ B.T.U.} \quad 104{,}400 \text{ B.T.U.} = -69{,}600 \text{ B.T.U.}$$

So that in the reduction of 44 pounds of carbonic acid to 28 pounds of carbonic oxide and the formation of another 28 pounds of carbonic oxide, there has been 69,600 B.T.U. absorbed.

When 1 pound of carbonic oxide is burnt to carbonic acid 4,370 B.T.U. are evolved; so that, following out our reactions, we get—

$CO + O = CO_2$
28 + 16 = 44 pounds formed, evolving $28 \times 4{,}370 = 122{,}360$ B.T.U.

These show that $\frac{52,200 \times 100}{174,560} = 29.96$ per cent. of the heat is given off in the production of the furnace gas.

Under the conditions of firing as now practised in most gas works, the greater portion of this heat is carried into the combustion chamber by the gases, and performs a certain amount of work; so that there is very little difference between the heat of combustion of the fuel in this way, and that which should be given out by burning the carbon directly to carbonic acid, supposing the air was just sufficient in both cases to consume it.

In the case of gaseous firing, it is possible to regulate the supply to almost the theoretical quantity, and get to perfect combustion; whereas with solid fuel burnt directly to carbonic acid, at least one-and-a-half times to twice the theoretical quantity is required to effect this; so that it is in this way possible to get a much higher temperature by these means than with the old direct fired system.

If steam and air are used in the production of the gas, the result produced in the generator is different; for when steam is blown over highly heated carbon, the following reaction take place—

$$\begin{array}{rrrrrr} H_2O & + & C & = & CO & + & H_2 \\ 18 & + & 12 & = & 28 & + & 2 \end{array}$$

The formula shows that 18 parts of water vapor are decomposed by the heated carbon, forming 28 parts of carbonic oxide and 2 parts of hydrogen; or, if this is represented by volume—

$$\begin{array}{rrrrrr} H_2O & + & C & = & CO & + & H_2 \\ 2 \text{ vols.} & & & = & \text{vols. } 2 & & \text{vols.} \end{array}$$

which shows that the resulting gas contains equal volumes of carbonic oxide and hydrogen.

Water vapor is a very stable compound, and in its formation much more heat is evolved than in the formation of carbonic acid; so that when it is decomposed by means of the incandescent carbon, this amount of heat, less that given out by the formation of the carbonic oxide, will have to be supplied to it. This can readily be seen by writing the formula and putting the thermal units under the equation, as was done in the foregoing ones. Thus—

$$\begin{array}{rrrrr} H_2O & + & C & = & CO & + & H_2 \\ 2 \times 61,500 & & & & 12 \times 4,350 & & \\ 123,000 \text{ B.T.U.} & & & & 52,200 = -70,800 \text{ B.T.U.} & & \end{array}$$

which show that the heat is rapidly absorbed and in large amount; so that the coke would rapidly cool below the point at which the reaction would be possible.

But when steam and air are sent through the heated carbon in certain proportions, so that the heat evolved by the action of air on the fuel is largely in excess of that required for the decomposition of the steam, it becomes possible to obtain a continuous supply of the gases. In practice, 4 or 5 times as much carbon is consumed by air as by steam. Assuming this to be 5 times, the following will show the reactions—

$$\begin{array}{rrrrrr} & & H_2O & + & C & = & CO & + & H_2 \\ \text{Heat evolved} & 123,000 \text{ B.T.U.} & & & 52,200 \text{ B.T.U.} & = & -70,800 \text{ B.T.U.} & & \end{array}$$

This shows that 12 pounds of carbon have been consumed by the steam; so that the carbon required by the air would be $12 \times 5 = 60$ pounds, which would be represented by the equation, thus—

$$\begin{array}{rrrrr} 5\,C & + & 5\,O & = & 5\,CO. \\ 5 \times 12 & + & 5 \times 16 & = & 5 \times 28 \\ 60 & + & 80 & = & 140 \text{ pounds produced;} \end{array}$$

and the heat evolved would be $60 \times 4,350$ B.T.U. = 261,000 B.T.U. Taking from this the 70,800 B.T.U. absorbed by the steam, it will be seen that the quantity of heat given off in the producer is 190,200 B.T.U., while producing 2 pounds of hydrogen gas, and 168 pounds of carbonic oxide, from 18 pounds of steam, 72 pounds of carbon, and 80 pounds of oxygen from air.

The composition of the gases already considered would be as follows:

Carbon and Air.	*Carbon, Air and Steam.*
CO....34.3 per cent. by weight.	CO....38.37 per cent. by weight.
N.....65.7 " "	H..... 0.46 " "
	N.....61.17 " "

From these, it will be seen that the gas produced by steam and air is richer in combustible gases than the one produced by air alone, though less heat has been generated in the producer in the formation of it. This is shown by the following calculations of the heat of formation from these percentages:

Carbon and Air.

$$\text{Carbonic oxide} = 34.3 \times \frac{12}{28} \times 4,350 = 64,945 \text{ B.T.U.}$$

Carbon, Air and Steam.

$$\begin{array}{rrrr} \text{Carbonic oxide} = 38.37 \times \frac{12}{28} \times 4,350 \ldots. = & 71,521 \text{ B.T.U.} \\ \text{Less hydrogen} = 0.46 \times 61,500 \ldots\ldots = - & 28,290 \text{ "} \\ & 43,231 \text{ B.T.U.} \end{array}$$

which shows that 64,945 — 43,231 = 21,714 B.T.U. less are evolved by the use of steam than without, in the production of 100 pounds of the gases, which means a saving in the brickwork of the generator.

The calorific value of these gases is different, which is shown as follows:

Carbon and Air.

Carbonic oxide	= 34.3 × 4,370.....	= 149,891 B.T.U.
Nitrogen	= 65.7.....	....
		149,891 B.T.U.

Carbon, Air and Steam.

Carbonic oxide	= 38.37 × 4,370.....	= 167,677 B.T.U.
Hydrogen	= 0.46 × 61,500.....	= 28,290 "
Nitrogen.....	.....	....
		195,967 B.T.U.

From these it will be seen that the gas made with steam and air has a calorific value of 46,076 B.T.U. more than the air produced gas. The amount of heat evolved in the producer by the use of steam and air is only 18.07 per cent. of the total heat evolved, against 29.96 per cent. with air alone.

Besides the proper regulation of the air, there is a further saving in the heating by waste heat of the primary and secondary air used for the production and combustion of the gases. The chief reason for this is that the products of combustion and the nitrogen present have to be heated up by the heat of combustion; so that there is a loss from this source so far as the useful heating effect is concerned, though the same number of thermal units are developed in the combustion of the fuel, whether nitrogen is present or not, though the temperatures produced are very different.

For the reecovery of the heat carried out by the waste products of combustion, various kinds of regenerators have been designed; but they have all practically the same principle in view. The saving due to these sources can readily be calculated if the temperature and specific heat of the air are known. Suppose that the primary air was heated to 500° F. above the atmospheric temperature, then the B.T.U. supplied from this would be—

$$500 \times 0.2377 = 119 \text{ B.T.U. per pound of air used.}$$

We have seen that 1 pound of carbon requires 1.33 pounds of oxygen to combine with it to form 2.33 pounds of carbonic oxide; and as air contains 23 per cent. by weight of oxygen, there would be required $\frac{1.33 \times 100}{23} = 5.78$ pounds of air to produce it. So that $119 \times 5.78 = 687.8$ B.T.U. would be recovered for every pound of carbon burnt, which would be equal to a saving of $\frac{687.8 \times 100}{4,350} = 15.8$ per cent. of the heat evolved in converting the fuel into carbonic oxide, or 4.7 per cent. of the solid fuel.

The heating of the secondary air still further effects a saving in fuel, which is shown in the following calculation, where it is supposed that the waste gases pass into the waste gas flue at a temperature of 1,750° F., and that the air is heated to this temperature—

$$0.2377 \times 1,750 = 416 \text{ B.T.U. per pound of air heated.}$$

As 1 pound of carbonic oxide burning to carbonic acid develops 4,370 B.T.U. while combining with 2.48 pounds of air, the saving would be $416 \times 2.48 = 1,031$ B.T.U. per pound of carbonic oxide consumed, which is equal to

$$\frac{1,031 \times 100}{4,370} = 23.5 \text{ per cent. of the fuel gas.}$$

Another source of saving is in the use of hot fuel drawn straight from the retorts into the furnace. Supposing that the coke left the retorts at a temperature of 1,750° F. above the atmosphere, then there would be added to the furnace—

$$1,750 \times 0.24 = 420 \text{ B.T.U. per pound of fuel added.}$$

If the fuel were perfectly dry, and at the temperature of the atmosphere, it would have to be heated up by the combustion of carbon to carbonic oxide, to bring it up to the temperature of reaction; so that by adding hot coke to the furnace, there is a saving of fuel equal to the B.T U. that are held by it, which, in the case just mentioned, would be—

$\frac{420 \times 100}{4,350} = 9.7$ per cent. of the heat evolved in the production of carbonic oxide.

If the cold coke or fuel has become slaked with water, it retains some of it (generally about 5 per cent.); which will have to be driven off by the heat generated in the furnace; so that there is a further loss in this case, which would be greater than with cold, dry coke. This is shown by the following calculations:

The heat required to raise 0.05 pound of water from 60° F. to 212° F. would be $0.05 \times 152 = 7.6$ B.T.U.; and to convert this into steam, $0.05 \times 966 = 48.3$ B.T.U. Then to raise this to the temperature of the hot coke added —$0.05 \times 0.48 \times 1,750 = 35$ B.T.U. So that the loss of heat units due to water would be 90.9 B.T.U.; while that required to raise 0.95 pound of fuel to 1,750° F. would be—$0.95 \times 1,750 \times 0.24 = 398.5$ B.T.U.

The total loss with slaked as compared with hot coke will be $90.9 + 398.5 = 489.4$ B.T. U. per pound of fuel. or

$\frac{100 \times 489.4 \times 100}{95 \times 4,350} = 11.8$ per cent. of the heat evolved in the producer.

In regenerative settings, the heat carried out by the waste gases is, when working properly, reduced to a minium. This can be determined if the weight of the products, the specific heats, and the temperature are known. Thus, in the case of the combustion of carbon in air, the products would be per 1 pound of carbon burnt 3.66 pounds of carbonic acid, and 8.9 pounds of nitrogen. If these are passing away from the regenerator at a temperature of 500° F. above that of the atmosphere, the loss will be—

$(3.66 \times 0.2387 \times 8.9 \times 0.2485 \times 500 = 1,542$ B.T.U. per pound of carbon, or $\frac{1,542 \times 100}{14,500} = 10.6$ per cent. of the carbon burnt.

Practical Working.—In starting to work regenerative settings it is first necessary thoroughly to dry the brickwork. In order to do this, the top sight hole plug should be removed and the damper closed. A small fire is then put into the furnace. As the brickwork dries, the amount of fire on the bars is gradually increased. During this time the furnace and charging doors are kept slightly open, so as to allow sufficient air to enter the setting for the complete combustion of the fuel. When steam ceases to issue from the top plug hole, the fire is increased and the dampers are opened wide; the top plug being put into its place, to cause the products of combustion to pass along the flues and carry the moisture away with them. The fire is now increased more quickly than before, until the bottom retorts become red hot, when the setting is ready for gaseous firing. The fires are now cleaned and filled with fuel.

When first putting on the primary and secondary air, it is best to put the secondary on first, and then open the primary slide about twice the area of the secondary slide. The charging and furnace doors are then closed; and the dampers are pushed back so as to leave them open about ½ inch. As the heating proceeds, the air slides and dampers are gradually opened until the required temperature is reached.

During this time of increasing the heats, very useful information can be got by observing the way the retorts are heating, which is useful in case of future alterations while the setting is working. In setting the air slides, even in the early stages of firing, it is best to adjust these as nearly as possible, so that there is only a slight excess of secondary air, in order to avoid local heating in the combustion chamber.

There are several methods in use of setting the air slides, one of which is to take out the first waste gas plug, and momentarily shut the secondary air slide, when a flame of unconsumed gas will be seen in the flue. The secondary air slide is then gradually opened, until the flame can only just be seen or just disappears. This method is capable of giving very good results if the plug is replaced after each slight opening of the secondary air slide, and the opening of the air slide stopped when the flame cannot be seen on suddenly pulling out the plug. In working this way, the damper is allowed to adjust its pull on the setting between each movement—so that a large excess of air is avoided; while if the plug is kept out during the alteration of the air slide, the action of the damper is partially neutralized, and when the plug is replaced, more air is drawn into the combustion chamber, causing a greater shortening of the flame than was required.

Another method is to try the pull on each of the air flues by means of a water gauge with a piece of glass tube attached to it by flexible tubing. The scale of the gauge is divided into $\frac{1}{100}$ of an inch. In using this, the gauge is held level in one hand, or rested on some support. The tube is then placed into the ports, and the difference of vacuum noted. From these differences the areas required can easily be calculated. With a little practice the slides can be set in a few minutes with sufficient accuracy that the excess of oxygen in the waste gases will amount to about 2 per cent.

The best method is, of course, by analysis of the waste gases themselves; but samples of these should be taken at the point at which the gases first enter the waste gas flue, for if the regenerators are "short circuiting," or passing secondary air through the joints in the brickwork into the waste gas flues, and the sample is taken just above the damper, the results will be very misleading, as any unburnt gas passing from the combustion chamber into the waste gas flues would be burnt as it passed along these on coming in contact with the air. The following analyses show this very clearly:

Waste Gas Sample Taken from Top Waste Gas Flue.

Carbonic acid	16.5 per cent. by volume.
Carbonic oxide	2.9 " "
Oxygen	Nil.

Sample Taken from Waste Gas Flue Above Damper.

Carbonic acid	11.6 per cent. by volume.
Carbonic oxide	Nil.
Oxygen	7.8 per cent. by volume.

It will be seen from these that, had the secondary air slides been altered according to any calculation made on the last analysis, such change would have been totally wrong.

When taking samples of gases, it should be remembered that the most fuel gas will be made when the fire has just been clinkered; so that the smallest excess of oxygen will be found in samples taken immediately after cleaning, and the largest excess just before clinkering time. The amount of oxygen that will be in excess in the waste gases just before clinkering greatly depends on whether the producer is working above its maximum producing power. The following tests for oxygen show this difference:

Half-Hour After Clinkering.	Half-Hour Before Clinkering.
1.3 per cent.	7.5 per cent.

The bed on which these tests were made had the secondary air slides open to admit just sufficient air to burn the largest amount of producer gas the furnace would give under the conditions to which it was set. The primary air slides should only be opened to admit sufficient air to make the amount of gas required to keep the retorts at the proper temperature, not only on account of the saving in fuel, but also to stop any local heating and cutting action that a large excess of air causes in the combustion chamber. This in some cases is due to the rapid formation of clinker, which stops the passage of primary air into the fuel for the production of gas, and the damper pull acting more on the secondary air than when the fire was first cleaned, causes a shorter flame that heats one portion of the retorts more than another.

If in the getting up of the heats care has been taken to increase the area of the slides and dampers by small amounts, and sufficient time has been allowed between each opening for the increased quantity of gas to take effect, this will in some measure be avoided.

In order to test whether this limit has in reality been passed, it is occasionally necessary to make an analysis of the furnace gases. To take a sample of gas from a furnace, the writer uses a length of ⅜-inch

iron tubing, which is pushed through the sight-hole over the gas nostrils. When the tube has softened, it is bent, and then pushed down through a nostril, so that the end of the tube will be about 12 to 18 inches below the arch. A plug, with a hole in it sufficiently large to allow the tube to pass through it, is then passed over the tube, and placed in the sight-hole; the plug being then made tight with a little fireclay. An aspirator, or sample bottle, is connected to the end of the tube, and the sample drawn from the furnace. In order to make sure that all the air has been expelled from the tube, etc., before the apparatus is disconnected, the vessel in which the sample is taken is filled several times with the gas.

There are many pieces of apparatus now used for the analysis of gases, such as those devised by Bunte, Orsat, Hempel and others, which are now widely used. The Hempel's apparatus, in combination with the combustion tubes devised by Jaeger, has been found useful for the purpose of making partial or complete analysis. The apparatus and reagents are as follows: One 100 c.c. burette complete, filled with saturated water. One potash pipette, containing a 33 per cent. solution of caustic potash to absorb the carbonic acid. Solid pipette, filled with sticks of phosphorus in water, for the absorption of oxygen. Two double liquid pipettes filled with ammoniacal cuprous chloride, to take out the carbonic oxide.

There are several ways of preparing this reagent, which will be found in the various text books on gas analysis. The following method is the one generally used by the writer: 60 grammes of sodium chloride (common salt) and 30 grammes of crystalized copper sulphate are dissolved in about 200 to 300 c.c. of water. When dissolved, the solution is poured into a flask containing a quantity of copper turnings and about 50 c.c. of commercial hydrochloric acid. The contents of the flask are then boiled for 15 minutes, after which the solution is poured into about 2 liters of water, when the cuprous chloride is precipitated as a white precipitate. This is then allowed to stand for an hour or two, so that the precipitate will settle. The liquid above the precipitate is then siphoned off, and the precipitate is dissolved in the least quantity of ammonium hydrate possible, and the solution is made up to 200 c.c. with water, which will be sufficient to fill one pipette. It will be found that 200 c.c. of the solution will dissolve about 800 c.c. of carbonic oxide before it is exhausted.

After the absorption of the carbonic oxide, the residual gas from a furnace gas, obtained from air, and the steam that is evaporated by the fire, will generally be found to be too poor in combustible gases to be exploded with air by means of the electric spark in the usual way, so that pure oxygen has to be employed in place of air. As this is not always at hand in a gas works laboratory, the following method was adopted: It will be seen that it depends on the fractional combustion of the hydrogen and marsh gas with copper oxide. The apparatus required is a small, hard glass tube, having a capacity of about 5 c.c., with the ends drawn out so as to form capillary tubes for connecting the apparatus together. This is filled with freshly ignited copper oxide, and placed in a stand, having a cover with a hole in it to take a cork and a thermometer. The stand should be of such a height that the tube can be connected to the pipette and the burette by means of small pieces of rubber tubing, and so that a flat-flame Bunsen burner can be placed under the tube to heat it.

The method of carrying out an analysis is as follows: The gas to be analyzed is drawn into the burette and the volume adjusted to the zero mark. After this has been done, the gas is passed into the potash pipette, in which it is shaken gently to promote absorption. The gas is then run back into the burette; and after it has been allowed to rest for three minutes (so that the water may drain down the sides of the burette), the liquid is levelled, and the volume of the gas absorbed is read off and noted in the laboratory book. The gas is then passed into the phosphorus pipette, and allowed to stand in it for three minutes, after which it is run back into the burette, and the volume absorbed read off as indicated above. For the determination of carbonic oxide, the gas is run into one of the cuprous chloride pipettes, in which it is shaken for three minutes, after which it is passed back into the burette, and the pipette is replaced by the second and freshest cuprous chloride one. The gas is passed into this and shaken for another three minutes, after which the volume of gas absorbed is read off, with the same precautions as for carbonic acid.

The burette containing the residual gas is now connected to the combustion tube by means of a small piece of capillary tubing and a small piece of rubber. The tube containing the copper oxide is now heated by the flat-flame Bunsen, until the thermometer stands steady at 250° C. When the temperature is steady, the free end of the combustion tube is connected to the potash pipette, and the gas passed slowly over the heated copper oxide three times. After the gas has stood in the burette for five minutes (or until the volume is constant), the amount of the gas that has disappeared is noted as hydrogen. The end of the combustion tube connected to the potash pipette is now disconnected, and the tube heated to redness. When the temperature has become constant, the gas is passed through it again three times, into the potash pipette, and back into the burette. After it has been allowed to cool, the volume of gas burnt is read off. The gas left in the burette is nitrogen, which can be read off directly from the burette.

The method of stating the results in the laboratory books is as follows:

CO_2 =	2.8 c.c. absorbed =	2.8 per cent.	by volume.
O =	2.8 " " =	0.0 "	"
CO =	33.4 " " =	30.6 "	"
H =	37.4 " " =	4.0 "	"
CH_4 =	38.4 " " =	1.0 "	"
N.....	=	61.6 "	"

The following are two analyses of gases taken from the producer at different times after the fire had been clinkered:

	One-and-a-Half Hours After.	*Seven-and-a-Half Hours After.*
CO_2	.... 5.2 per cent. by volume.	.. 2.8 per cent. by volume.
O	.... 0.0 " "	.. 0.0 " "
CO	....27.4 " "	.. 31.3 " "
H	.... 5.6 " "	.. 5.0 " "
CH_4	.... 0.6 " "	.. 0.2 " "
N	... 61.2 " "	.. 60.7 " "
Waste gases contained—		
	Oxygen 2.6 per cent. by volume.	Oxygen 7.8 per cent. by volume.

When these analyses are calculated to the amount of the waste gases they will produce, containing the amount of air found in the actual tests, it will be seen, that, an hour and-a-half after clinkering 197.6 volumes, and seven-and-a-half hours after 287.87 volumes had been produced from 100 volumes of furnace gas, which is an increase of 46 per cent. As the dampers, etc., had not been moved during these experiments, it will be seen that only about 54 per cent. of producer gas was being made seven-and-a-half hours after clinkering, taking that made at an hour-and-a-half after as 100. During these tests, the average temperature of the retorts was 1,670° F. On cutting down the amount of primary air, and readjusting the secondary air and dampers, the difference in the calculated volumes of the waste gases became 13.5 per cent. for the same periods after clinkering, during which time the average temperature of the retorts was 1,760° F., and the saving in fuel was 5 pounds per 100 pounds of coal carbonized over that in the first experiments.

These show the importance of the proper regulation of the primary air supply as well as of the secondary air, if the maximum saving is to be secured from the gaseous firing.

As a general rule, the furnace gas should not contain more than 3 or 4 per cent. of carbonic acid, and the waste gases not more than 4 per cent. excess of oxygen just before clinkering time, when the generator is working properly.

It frequently occurs that a bed of retorts which has been working satisfactorily for some time after careful adjustment, will gradually cease to heat evenly, though the air-slides and dampers have not been interfered with. Sometimes the heat will be found to have gone to the bottom retorts, and sometimes to the top ones. When the bottom retorts are found to be heating most, or more than they were intended to, it is necessary to cut off a little secondary air, so that the flame in the combustion chamber will become longer, and thus heat higher up the setting. The cause of this shortening of the flame is in many cases due to the fuel containing more ash than that which was being used when the bed was first set to work; for with the increased amount of ash, the grate-bars become clinkered up more quickly, and soon stop the free passage of primary air into the fuel, so that the quantity of producer gas is less than that to which the slides were set. Another cause is allowing the bed of the fuel to get too low on the grate-bars, when the carbonic acid is not completely converted into carbonic oxide, or the primary air has too free a passage through the fuel, and the setting is converted in some measure to a direct-fired one. It is necessary to keep the bed of fuel in the furnace from 2 feet to 4 feet thick when air alone is used, and from 3 feet to 6 feet for steam and air, in order to insure the best results from the producer.

When the heat has been traveling towards the top of the bench, short-circuiting should be looked for, as it shows that the flame has

become too long for even heating. This is due to insufficient air being admitted into the combustion chamber to burn the gas within required limits. In order to do this, one of the top plugs in the wastegas flue should be suddenly drawn from the sight-hole, while a sharp lookout should be kept for any unburnt gas, which, as soon as it reaches the air, will burn with a blue flame. When this is found, more secondary air should be admitted, in order to burn the gas in the combustion chamber. In very bad cases, it is sometimes necessary to increase the damper in order to get sufficient air into the setting, as this cannot be dealt with by opening the secondary air slide. If no short-circuiting can be found, the lengthening of the flame may be due to the fuel containing less ash than that which was first used; so that the quantity of producer gas will be larger. In this case, the primary air slides should be shut a little at a time, until the gas is properly burnt.

When the dampers are altered to increase or decrease the temperature of the retorts, care should be taken to see that the air slides are reset so that the maximum efficiency can be got from the setting and the fuel used.

In conclusion, I may say that it is impossible, in a paper of this description, to go into every point that may arise in this most interesting subject.

Heating and Ventilating of Foundries and Machine Shops.

[Paper read by MR. W. H. CARRIER (Buffalo) at the Milwaukee Convention of the American Foundrymen's Association.]

The paper sets forth the nature of the difficulties to be overcome in the satisfactory heating of shop buildings and shows the adaptation of the fan system to the solution of these difficulties.

Heat losses occur in the building from two causes: First, by the direct transmission of heat by radiation, through the walls and exterior surfaces of the building, and, second, by the infiltration of cold air from without. In designing a heating plant the first of these losses may be very accurately determined by referring to tables which have been prepared showing the amount of heat radiated under different conditions through various thicknesses of walls, windows, doors, roof, etc. The heat lost through infiltration varies so greatly in various sizes and constructions of buildings that no definite rule can be given. The allowance to be made for this is necessarily a result of experience and a careful test of previous installations.

In either fan or direct radiation systems difficulty is liable to be experienced from the heated air immediately rising and forming a stratum of heated air just beneath the roof. In machine shops and foundries, owing to their height and to the great amount of skylight surface which is always provided in the best modern construction, the loss occasioned by this action of heated air may be considerable, and its prevention is a serious problem. With the fan system, however, the distribution of the heated air is entirely mechanical and affords an opportunity for utilizing its heating effect to the very best advantage. Various methods of distribution have been devised with the fan system whereby the effect of a rising current of heated air is almost entirely avoided. These systems, in general, depend upon securing a perfect diffusion of heated air along or near the floor line and will be described in detail later.

A second difficulty experienced in high buildings is the effect due to outward leakage of the heated air at the upper part of the building and a consequent inward leakage of cold air along the floor line. In large shops this layer of cold air may frequently be found to extend from 4 to 6 feet above the floor, while the amount of heat lost due to the high temperature in the upper part of the buildings may be much more than sufficient to secure a satisfactory heating effect throughout if properly applied. The most effective remedy for this evil is to maintain a slight pressure within the building by means of a fan, which takes a portion of its air from without.

A third difficulty presenting itself in buildings covering large area and having a large amount of skylight is the cold down draft, which the cooling effect of the skylights has a tendency to produce. In very wide buildings where heat is distributed only along the walls this effect is noticeable, and as it comes directly upon the heads and shoulders of the workmen and is in the part of the building most used, it is very objectionable.

Methods of Heating.—In general buildings may be heated in two ways: First, by keeping the walls and roof warm. This is accomplished in direct radiation system by placing coils along the walls, and in the fan system by blowing the heated air toward the walls. A second method is to heat the air within the building directly. This can be accomplished in a satisfactory manner only by an indirect or fan system. Of these two systems it may be said that if either is used exclusively the second method is preferable, since it is the more economical. In the first method it is quite evident that if the walls be kept warm radiation will not occur to any great extent from the interior of the building, and the heating effect will be satisfactory. On the other hand it is equally evident that the radiation through the walls caused by heating them to a higher temperature occasions a much greater radiation loss than would occur if the room temperature had been secured by heating the air directly. Since the heat transmitted by wall coils is chiefly direct radiation the loss occasioned by the direct transmission of heat through the walls with this system is very great and may be as high as 25 per cent. or more of the total radiation.

With the fan system the method of supplying and distributing the air in the building is the consideration of chief importance. The usual methods of supplying heated air, are, first, where the air is taken entirely from without doors and is forced directly into the building through distributing ducts. This method is generally known as the plenum system, and the pressure produced in the building causes a continuous exit of air from the building, either through the natural openings, as is usually the case in factory and other large buildings, or through special vent openings provided for the purpose, as in public buildings.

A second and more common method for shop buildings where forced ventilation is not a necessity is to draw the supply of air entirely from within the building and again forcing it through the distributing ducts. This causes a continuous circulation of the air within the building, and when properly applied secures excellent results.

The first of the above methods has the advantage of securing an excellent ventilation, and in the instance of foundries this is often desirable. Another advantage possessed by the plenum system is that it produces a continuous outflow of air through all the crevices and openings in the building, which would otherwise be admitting cold air from without to settle along the floor and prevent satisfactory heating. In buildings of loose construction this is frequently the only system which can be successfully operated.

The air return system often has an advantage over the plenum system, in that all the heat supplied to the air is effective in heating the building, but does not possess the advantage of producing a plenum in the building.

Ideal System.—The ideal system is a combination of the plenum and return systems and should always be used where possible. In this system the great portion of the air is returned to the apparatus, but sufficient air is continuously taken from without through a fresh air connection to create a plenum within the building and prevent the inward leakage of the cold air along the floor. In this manner the natural leakage is supplied, not by inflow of cold air through the crevices around the doors and windows but by air passed through the apparatus and heated to an effective degree. This system has been found by test to be more economical than air return alone. The proper amount of air to be introduced from without is determined by securing a point where the noticeable inward flow of air around the doors or windows ceases. If the plenum is carried beyond this point there will be a loss due to unnecessary heating of the outdoor air.

Systems of Air Distribution.—There are several systems of distributing the supply of heated air. A method usual in public and office buildings, and sometimes employed in factory buildings, is the vertical duct system by which the air is admitted through vertical flues or ducts built in the walls at a point about 8 feet above the floor. A method of distribution quite similar to this is one where the air is first blown into brick ducts placed underneath the floor. From these ducts vertical galvanized iron risers are arranged along the walls.

This system is also frequently very successfully employed in foundries. Advantages of this system are, first, that there is no overhead piping in the way of cranes, etc.; second, that the greater portion of the distributing ducts are brick and are not subject to deterioration. The third and principal advantage is that the air can be distributed by this means where most needed. This system is sometimes somewhat modified by placing the outlets close to the floor and blowing downward directly along the floor. This secures a perfect diffusion of the heated air at the floor line and avoids any drafts which would be objectionable.

Another system which has proved very satisfactory is that in which a distributed air return duct is employed. This approaches very closely in principle to the plenum system used in public buildings, and is a combination of both plenum and exhaust systems. In the Philadelphia

& Reading shops at Reading, Pa., instead of employing one or two large units, seven separate sets of apparatus have been provided, placed in small fan houses built at intervals at either side of the building. The peculiar feature in this and similar installations is that no distributing ducts or piping for the heated air are used; the air being blown directly into the building at about 8 or 10 feet above the floor through an outlet branching in three directions, and through which the air passes at a comparatively high velocity. The distribution is effected entirely by return vent ducts, distributed at frequent intervals along the walls, opening into large return air tunnels, which are provided on either side of the building and serve the additional purpose of affording a convenient place for locating steam and water mains, and also electric light and power mains. Provision is made for taking a portion of the air from without doors to secure a plenum. One great advantage of this system is that it removes all cold air leaking into the building at the floor line, as well as that produced by the cold down draft next to the walls. Further, a perfect distribution is secured in all parts of the building, and the cost of installation is reduced to a minimum.

Excellent results can be secured by the use of overhead piping, providing it is not placed at too great a distance above the floor. The chief advantage of the overhead system is the saving in first cost, since on account of the high temperature and velocity of air in the distributing pipes a great amount of heat can be transferred with a very small amount of material. The cost of the galvanized iron distributing system of air ducts is usually a small portion of the total cost. The best results are secured with outlets at from 12 to 18 feet. Above this height it is preferable to use drop pipes extending downward along the columns where they will not interfere with traveling cranes.

In many instances a system of elaborate distribution is impracticable or undesirable. In such cases a centrally located apparatus or discharge pipe may be used. From this point the air is blown in all directions, and a circulation is produced by an exhaust connection to the fan inlet. In such instances very effective heating has been secured even where it was required to blow the air long distances. Perhaps as good an example of the successful operation of such a system may be found in the Buffalo Forge Company's installation in the foundry buildings of the General Electric Company at Schenectady. This foundry, which is probably one of the largest in the world, is heated in an entirely satisfactory manner with a few large branch outlets. Since the plant was installed a large addition has been built on one end of the building. This addition is satisfactorily heated by a branch inlet situated at over 200 feet from the further end, which shows how thorough a distribution may be secured by a forced circulation.

Production of Natural Gas in 1902.

The annual report of the United States Geological Survey on the production of natural gas, which has been prepared by F. H. Oliphant, shows that the value of this product consumed in the United States in 1902 was $30,754,957, a value greater than that of any previous year. At an average price of 15 cents per 1,000 cubic feet, this sum represents a production of 205,033,000,000 cubic feet. Assuming that 20,000 cubic feet of natural gas be taken as equal to 1 ton of coal, the quantity of natural gas consumed in 1902 represents, in round numbers, 10,250,000 tons of coal, valued at $3 per ton. The value of the coal and wood actually displaced is reported as $39,660,563, so that the use of the natural gas resulted in an apparent saving to its consumers in 1902 of $8,905,606. The value of the gas produced and sold in 1902 was $3,688,880 greater than that of 1901, an increase of over 13 per cent. It may be interesting to note also that the value of natural gas in 1902 was 43.3 per cent. of the value of the crude petroleum produced in the same year. When the value of the coal and other fuel displaced by the natural gas is taken into consideration, it amounts to very nearly 56 per cent. of the value of the crude petroleum. Natural gas is a finished product, however, while petroleum is a crude commodity, requiring treatment before it can be marketed.

There were 14,349 wells producing natural gas at the close of 1902, of which number 95 were shut in and not in use, leaving 14,254 wells that were in use. There were 2,722 new productive wells completed during 1902, 579 wells were dry or unproductive and 1,238 wells were abandoned. At the close of 1901 there were 12,865 producing wells, so that 1902 shows a gain of 1,484 productive wells. In 1902 there were laid 3,002 miles of main line of pipe from 2 inches up to 20 inches in diameter. The total miles of main line in use at the close of 1902 were 24,850, sufficient to girdle the globe.

There was an important increase in the number of companies supplying gas in 1902, and also in the number of industrial establishments employing this fuel.

Decrease in Pressure.—As in 1901 the tendency during 1902 was toward decreased pressure in the principal fields, although the consumption materially increased. It is almost inconceivable that even after the commercial value of natural gas for heat, light and power came to be fully appreciated, reckless and appalling waste should have been permitted. It is but 20 years ago that the most important pipe lines supplying manufactories of Pittsburg, especially the iron, steel and and glass works, were completed. In 1886 the great Findlay field in Ohio began to be a prominent factor, and was followed soon after by the development of the vast Indiana field. With these remarkable and sudden discoveries of such quantities of natural gas that were before unknown, the general impression was strengthened that the reservoirs of this remarkable fuel were practically inexhaustiblo. Northwestern Ohio and Central Indiana vied with Western Pennsylvania in consuming the greatest quantity of natural gas in the shortest time by almost turning night into day. The climax was reached in 1888, when it has been estimated that not less than 750,000,000,000 cubic feet of natural gas were consumed and wasted. For this immense quantity only $22,630,000 was paid. This includes what was received for all the natural gas consumed in the United States that year, at an average price of 3 cents per 1,000 cubic feet. If sold for only 10 cents per 1,000 cubic feet, the gas would have yielded $75,000,000. It took the place of about 18,000,000 tons of coal. The total value of the petroleum produced in the United States that year was only $18,000,000.

The decline in value and quantity continued until the years 1895 and 1896, when the value of the product for each of these years was only $13,000,000. From this time there has been a general increase in value and an increase in quantity. The new production, chiefly from West Virginia, has more than made good the decline of the older fields.

Methods to Prevent Waste.—Recent years have developed greatly improved joints for large gas mains, in which indiarubber plays an important part. Hereby a vast number of leaks are stopped, which have in the past been a very serious loss when the larger sizes of screw pipe were used. By this plan, also, expansion is provided for. The last three or four years have witnessed the construction of much longer and larger lines than were formerly in general use. The capacity of large lines has been demonstrated to be greater than that formerly assigned to them by the general formula.

The introduction of the natural gas meter has been one of the most successful saving appliances, and has brought about a reform in the economical consumption in the household and elsewhere. This has been one of the main factors in showing increased revenue since 1896, although there has also been a considerable increase in the quantity marketed. Another economical reform, gradually carried out, was in the better distribution of the regulators which feed from the higher to the lower distributing mains, together with the enlargement of many of the mains, which caused a lower and more even pressure throughout the plant. Originally the gas pressure in the wells was sufficient to transport large quantities in ordinary sized pipes to points of consumption many miles distant. In many instances during recent years the gradual falling off of the natural pressure has made it necessary to install powerful pumping or compressing machinery, which was described in detail in the report for 1900. These pumping plants are usually very fine specimens of mechanical engineering, and their economical achievements are equal to the best results attained elsewhere.

By far the most economical results have been secured by large gas engine compressors, in which natural gas is exploded instead of steam being used, and in which 9 cubic feet have developed 1 horse power per hour, while working up to about 1,000-horse power capacity. Thirty cubic feet of gas have been compressed from 0 to 270 pounds pressure to the square inch by the consumption of 1 cubic foot of natural gas, whereas double that amount of gas is consumed under boilers supplying double expansion condenser steam engines to do the same kind of work.

In recent years there has developed a general extension and enlargement of many of the large lines supplying Central Western Pennsylvania and Northeastern Ohio to the deep and prolific fields of Southwestern Pennsylvania and Western West Virginia, which are now operated in a most economical way, enforced by the dearly learned lessons of the reckless exhaustion of the original fields of Pennsylvania, Ohio and Indiana.

Natural Gas Engine.—The natural gas engine has been extensively introduced throughout the gas belt. Its first application was made about 10 years ago, when it was used in pumping petroleum wells. Afterward, ranging from 5 to 500-horse power, it was extensively intro-

duced into manufacturing plants. It has successfully demonstrated its economy and reliability. It is particularly applicable to the pumping of oil wells and to driving pipe line pumps, owing to the large number of points that are often widely separated and are difficult to supply with other fuel.

The gas engine has in very many instances replaced the steam engine and boiler. In some instances this has been done by removing the steam engine entirely, in others by the substitution of a gas cylinder for a steam cylinder on the same engine bed. The dispensing with the troublesome boiler and the substitution of a much more economical engine have placed in the hands of the oil operator a much cheaper source of power not subject to the contingencies of the former method, with a great saving of labor and material, and also a great saving in the quantity of gas consumed. To offset this, however, it must be remembered that the ordinary oil pumping plant is a very extravagant combination, so far as economy in the use of steam is concerned.

Production by States.—The value of the natural gas produced in the United States in 1901 and 1902 by States was as follows: California, 1901, $67,602, 1902, $116,334; Colorado, 1901, $1,800, 1902, $1,900; Illinois, 1901, $1,825, 1902, $1,794; Indiana, 1901, $6,954,566, 1902, $7,028,494; Indian Territory, 1901, none, 1902, $360; Kansas, 1901, $659,173, 1902, $823,304; Kentucky, 1901, $270,871, 1902, $328,681; Missouri, 1901, $1,328, 1902, $2,154; New York, 1901, $293,232, 1902, $346,791; Ohio, 1901, $2,147,215, 1902, $2,344,988; Pennsylvania, 1901, $12,688,161, 1902, $14,324,098; South Dakota, 1901, $7,255, 1902, $7,280; Texas, 1901, $18,577, 1902, $14,953; West Virginia, 1901, $3,954,472, 1902, $5,413,826. Total, 1901, $28,066,077, 1902, $30,754,957.

The reports for 1902 show a total of 2,116 companies or individuals engaged in the production of natural gas, an increase of 571 as compared with 1901. Many of these, however, were individuals owning a single well, which accounts in part for the large increase. A number of iron, steel and glass works in Pennsylvania and a number of glass works in Indiana have their own natural gas plants. The industrial establishments supplied during 1902 numbered 8,094, including 55 iron mills, 96 steel works, 360 glass works and 7,538 other establishments. The iron mills were located as follows: Pennsylvania, 30; Indiana, 12; Ohio, 8; West Virginia, 3; Kansas, 1, and Kentucky, 1; while steel mills were distributed as follows: Pennsylvania, 69; Indiana, 7; Ohio, 9; West Virginia, 8; New York, 1, and Kentucky, 2. In addition to the consumption by industrial enterprises there were 505,583 domestic consumers supplied in 1902, and it is asserted that not less than 3,850,000 individuals are thus supplied with light and fuel.

[Concluded from Vol. LXXIX., Page 1011.]

American Central Electric Station Statistics.—No. IV.

What becomes of the current used and sold is an important consideration, and a large amount of data is given bearing upon this point. As to the arc light service, the following table is of interest:

Arc Lamps—Private and Municipal Stations, and Percentage each Class is of Total: 1902.

Kind of Lamp and Character of Service.	Total.	Private Stations. Number.	Private Stations. Per Cent.	Municipal Stations. Number.	Municipal Stations. Per Cent.
Aggregate	385,698	334,903	86.8	50,795	13.2
Commercial or other private, total	173,973	168,180	96 7	5,793	3.3
Open	42,988	41,622	96.8	1,366	3.2
Inclosed	130,985	126,558	96 6	4,457	3.4
Direct current	104,176	101,849	97.8	2,327	2.2
Open	38,120	36,856	96.7	1,264	3.3
Inclosed	66,056	64,993	98.4	1,663	1.6
Alternating current	67,538	64,085	94.9	3,453	5.1
Open	3,733	3,631	97.3	102	2.7
Inclosed	63,805	60,454	94.7	3,351	5.3
All other	2,259	2,246	99.4	13	0.6
Open	1,135	1,135	100.0	....	....
Inclosed	1,124	1,111	98.8	13	1.2
Public, total	211,725	166,723	78.7	45,002	21.3
Open	138,684	108,082	77.9	30,602	22.1
Inclosed	73,041	58,641	80.3	14,400	19.7
Direct current	154,749	119,520	77.2	35,229	22.8
Open	125,298	96,659	77.1	28,639	22.9
Inclosed	29,451	22,861	77.6	6,590	22.4
Alternating current	48,063	38,316	79.7	9,747	20.3
Open	4,630	2,681	57.9	1,949	42.1
Inclosed	43,433	35,635	82.0	7,798	18.0
All other	8,913	8,887	99.7	26	0.3
Open	8,756	8,742	99.8	14	0.2
Inclosed	157	145	92.4	12	7.6

In addition to the 385,698 arc lamps shown for central electric stations, the street railways operating electric light stations report 33,863 arc lamps, making the total in the United States 419,561. This does not include, of course, a large number operated in isolated plants of all kinds, as previously pointed out. The total annual income derived from arc lighting of every description, with the exception of isolated electric plants, is $27,408,708, giving an average of $65.33 per lamp, regardless of the daily hours of burning.

Of the total number of lamps reported for central electric stations, 334,903, or 86.8 per cent., are in use by stations operated under private ownership and 50,795, or 13.2 per cent., by stations under municipal control; 173,973, or 45.1 per cent., are engaged in commercial or other private lighting, and 211,725, or 54.9 per cent., in lighting streets, parks and public buildings; 181,672, or 47.1 per cent., are of the open variety, and 204,026, or 52.9 per cent., are of the inclosed. There are 258,925 lamps, or 67.1 per cent. of the total, operated by the application of direct current, and 115,601, or 30 per cent., by alternating current.

With regard to the lamps classified as "all other" this should be understood as referring to lamps which are not, strictly speaking, in the arc lighting category on private or public circuits. There are, throughout the country, a great many focusing and small projector lamps which are not known as arc lights, although the current is made to produce light by passing between two carbon points. These lamps are used in theaters, for stage projection purposes, in photographic studios, engraving shops, and daily newspaper offices for the quick production of photographs, engravings, etc. To add such arc lamps to the class devoted strictly to purposes of lighting buildings and streets would be misleading, and, therefore, the attempt has been made to segregate them as far as possible, although it will be understood, of course, that these are operated on the ordinary central station circuit.

Of the 334,903 arc lamps reported by stations operated under private ownership, 168,180, or 50.2 per cent., are used in commercial or other private lighting, furnishing an income of $8,220,154, or $48.88 per lamp; and 166,723, or 49.8 per cent., are used in public lighting, furnishing an income of $13,871,646, or $83.20 per lamp. Of the 50,795 lamps reported by municipal stations, 5,793, or 11.4 per cent., are used in private lighting, furnishing an income of $240,166, or $41.46 per lamp; and 45,002, or 88.6 per cent., are used in public lighting, with an estimated income of $3,149,079, or $69.98 per lamp. The income of municipal stations from public lighting is estimated for each station at the commercial rates prevailing in the community, The number of lamps, however, is not the number actually performing service at any one time, but only the number in position to render service, and, therefore, to earn an income. Including the lamps operated from stations controlled by electric railway companies, there are 195,122 of the open variety and 224,439 of the inclosed.

The general introduction of meters and the application of meter rates to the sale of electric current have made it unnecessary, and even impossible, to keep a record of the number of incandescent lamps in service, and in the majority of cases the numbers reported are estimates; but, while the totals are not the result of an actual count, they may be accepted as a close approximation of the actual number of lamps wired and ready for use at the end of the year covered by this report. The table herewith summarizes the totals for the United States and shows the proportion in private and municipal stations.

Incandescent Lamps—Private and Municipal Stations, and Percentage each Class is of Total: 1902.

Kind of Lamp and Character of Service.	Total.	Private Stations. Number.	Private Stations. Per Cent.	Municipal Stations. Number.	Municipal Stations. Per Cent.
Aggregate	18,194,044	16,616,593	91.3	1,577,451	8.7
Commercial or other private, total	17,738,384	16,243,853	91.6	1,494,531	8.4
16-candle power	15,261,067	13,890,281	91.0	1,370,786	9.0
32-candle power	514,679	484,246	94.1	30,433	5.9
All other candle power	1,962,638	1,869,326	95.2	93,312	4.8

Kind of Lamp and Character of Service.	Total.	Private Stations. Number.	Private Stations. Per Cent.	Municipal Stations. Number.	Municipal Stations. Per Cent.
Public, total.....	455,660	372,740	81.8	82,920	18.2
16-candle power.	296,776	235,842	79.5	60,934	20.5
32-candle power.	59,988	47,063	78.5	12,925	21.5
All other candle power.....	98,896	89.835	90.8	9,061	9.2

There are 16,616,593 incandescent lamps of all varieties reported for stations operated under private ownership. Of this number, 16,243,853, or 97.8 per cent., are used for commercial or other private lighting, and 372,740, or 2.2 per cent. for public lighting. Of the 1,577,451 lamps reported for municipal stations, 1,494,531, or 94.7 per cent., are used for commercial or other private lighting, and 82,920, or 5.3 per cent., for lighting streets, parks and other public places.

The total number of "all other candle power" incandescent lamps, 2,061,534 is composed of small lamps of from 4 to 8-candle power, used for advertising and decorative purposes, and of a comparatively small number of lamps of high candle power, such as 50-candle power. It is estimated that the equivalent in 16-candle power lamps would be about half the number, or 1,030,767. Doubling the number of 32-candle power lamps in order to reduce them to a 16-candle power basis and including the incandescent lamps reported by electric railway companies, we have an aggregate equivalent of 19,171,544 as the number of 16-candle power incandescent lamps wired and ready for use in the United States so far as central stations are concerned. The annual income from these lamps is reported as $48,222,108, or $2.52 per lamp. Reducing to a 16-candle power basis the incandescent lamps reported for central electric stations, we have an equivalent of 17,737,944 lamps, of which 16,168,321, or 91.2 per cent., are operated by private stations, and 1,569,623, or 8.8 per cent., by municipal stations. Of the total number of lamps for both classes of stations, 17,271,744, or 97.4 per cent., are used in commercial or other private lighting, and 466,200, or 2.6 per cent., in public lighting.

The following statement shows the number of arc and incandescent lamps reported by private and municipal stations as used for commercial or other private and public service, and also the total annual income from each variety of lamp, with the average income per lamp:

Number of Lamps in Service, Total Income, and Average Income per Lamp.

Items.	Arc Lamps—Commercial or other Private Service.	Arc Lamps—Public Service.	Incandescent Lamps—Commercial or other Private Service.	Incandescent Lamps—Public Service.
Private stations—				
Number of lamps....	168,180	166,723	16,243,853	372,740
Total income.....	$8,220,154	$13,871,646	$39.039,557	$2,257,927
Ave. income per lamp	$48.88	$83.20	$2.40	$6.06
Municipal stations—				
Number of lamps....	5,793	45,002	1,494,531	82,920
Total income.....	$240,166	$3,149,079	$2,868,296	*$491,322
Ave. income per lamp	$41.46	$69.98	$1.92	$5.93

*Estimated value if paid for at prevailing rates.

There are 99,102 stationary power motors of all kinds, with a capacity of 619,283-horse power, reported as being in operation by private stations, and 1,962, with a capacity of 5,403-horse power in operation by municipal stations, making an aggregate of 101,064 stationary motors, with a capacity of 624,686-horse power. No inclusion is made, however, of fan motors, nor of the 2,370 railway motor cars served.

As to the circuits employed in the industry, the following figures are reported:

Miles of Electric Line Construction—Private and Municipal Stations and Percentage each Class is of Total: 1902.

Items.	Total.	Private Stations.	Municipal Stations.	Private Stations.	Municipal Stations. Per Cent.
Total:					
Mains...	107,263.63	93,352.95	13,910.68	87.0	13.0
Feeders .	17,880.51	16,452.28	1,428.23	92.0	8.0
Underground—					
Mains...	5,847.71	5,408.55	439.16	92.5	7.5
Feeders .	2,276.55	2,262.02	14.53	99.4	0.6
Overhead—*					
Mains...	101,383.76	87,913.13	13,470.63	86.7	13.3
Feeders .	15,592.59	14,181.75	1,410.84	91.0	9.0
Submarine—					
Mains...	32.16	31.27	0.89	97.2	2.8
Feeders .	11.37	8.51	2.86	74.8	25.2

*Includes 79.50 miles of mains and 121.25 miles of feeders for electric railway service owned by lighting company.

There are 125,144.14 miles of main and feeder wires reported for both private and municipal stations. Of this total, 109,805.23 miles, or 87.7 per cent., are reported by private stations and 15,338.91 miles, or 12.3 per cent., by municipal stations. The mains and feeders for underground circuits measure 8,124.26 miles, or 6.5 per cent. of the total, and the overhead circuits 116,976.35 miles, or 93.5 per cent. Comparatively few stations have a record of the actual length of the wires strung and ready for service, but the amounts reported are careful estimates prepared by, or under the direction of, the management of each station. In several instances it has been found that electric light stations supply current to electric railway companies, and that, in the majority of such cases, the railway companies own the main and feeder wires over which this current is supplied. There are, however, 199.75 miles of mains and feeders for electric railway service owned by the central stations. These quantities are included in the statistics presented.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

A SPECIAL meeting of the shareholders in the Isbell-Porter Company was held the 18th ult., and the following Directors were chosen: Charles W. Isbell, Chairman; A. F. Wehner, J. S. De Hart, Jr., R. K. Wehner and Brainard Avery. This completes the reorganization of the Company as outlined in our issue for October 19th last. The business of the Company will be under the direct management of the following corps of engineers: J. S. De Hart, Jr., M.E., President; A. F. Wehner, Ph.B., Secretary and Superintendent; R. K. Wehner, Ph.B., Treasurer; S. F. Hay, Chief Draughtsman; G. P. Richardson, M.E., Engineer of Construction; and J. A. Williamson, M.E., Assistant Superintendent.

SUPERINTENDENT N. O. GOULDING, of the Natick (Mass.) Gas Light Company, is meeting with great success in the placing of gas arc lamps in competition with the Edison Electric Illuminating Company, of Boston, which concern supplies electric service for all sorts in Natick. In fact, the electricians are now giving a service for the 24 hours, and are making lamp renewals without charge.

AT the annual meeting of the Rochester (N. H.) Gas Light Company the Directors elected were: A.W. Hayes, Samuel B. Felks, P. H. Hartigan, J. B. Stephens and S. D. Wentworth.

A CORRESPONDENT forwards the following under date of December 26th, from Windsor, Can.: "The case against the Windsor Gas Company, recently tried in the Police Court, resulted in a sorry fizzle in so far as the prosecution was concerned. Mr. A. F. Nash, the Dominion Government Inspector of Gas and Meters, is undoubtedly a good gas man, but as a prosecuting attorney he is a dismal failure. Perhaps the fault was not all the Inspector's, although from the first it was evident that he had no case against the Company. The prosecution was made under the sections of the Inland Revenue Act. The Act, which has been in effect for a number of years, is as valueless a minute as many other of the Government's red tape measures. No standard either of regularity or pressure is stated in the Act, and as Mr. Rodd, the Company's counsel stated, the Magistrate, like Frank Sullivan of Gamey fame, was asked by the Inspector to pursue a phantom. Inspector Nash was formerly Manager of the Windsor Gas Company and now covers a district reaching from this city to Woodstock. He has had many years experience in the business. His contention was that the Company should provide a light of sufficient brilliancy and to this end made his test at the flame instead of at the meter. The Company contends that it is not responsible for the light in so long as it produces the pressure at the meter that is considered reasonable, and the lights might be imperfect in the consumer's failure to have clean and properly protected pipes. Inspector Nash claimed that this was a test case to indicate whether or not the Act was sufficiently clear to be in the interests of the public and expressed his intention of sending the Magistrate's ruling to the Department. The question one would naturally ask is why he didn't make his test case elsewhere than in Windsor where he was formerly Manager and where his action might be misunderstood and where his prosecution of the Company might cause a suspicion that he had a personal motive of jealousy at the Company's success or otherwise in making his charge. He admitted that his object was to have the matter ventilated. Magistrate Bartlett wanted him to admit that the Company was doing very well by the public in the quality of gas supplied as was his own opinion, but the Inspector was silent. Mr. Baxter for the Company presented a circular card on which is auto-

matically registered the pressure at various hours and which absolutely contradicted the Inspector's deductions. Contrary to the oft-repeated proverb, one or other of those sets of figures lied. After some further discussion the Court ruled that there was no cause for censure."

THE Newton and Flushing (N. Y.) Gas Company has declared a dividend of 3 per cent. on its preferred stock and one of 1 per cent. on the common shares, both payable February 1st.

THE certificate of incorporation of the Hartford (Conn.) Gas Securities Company, which concern proposes to operate the Hartford City (Conn.) Gas Light Company, which was recently filed with the Secretary of State, provides as follows:

"We, the subscribers, certify that we do hereby associate ourselves as a body corporate and politic under the statute laws of the State of Connecticut, and we further certify:

"*First.*—That the name of the corporation is the Hartford Gas Securities Company.

"*Second.*—That said corporation is to be located in the town of Hartford in the State of Connecticut.

"*Third.*—That the nature of the business to be transacted and the purposes to be promoted or carried out by said corporation are as follows:

"To purchase or otherwise acquire any or all of the shares of the capital stock of the Hartford City Gas Light Company, a corporation duly incorporated under a resolution of the General Assembly of the State of Connecticut, and located in the town of Hartford; to own, hold, manage and control said shares; and to exercise and enjoy any or all of the rights, privileges and benefits of full ownership of said shares.

"In addition to the foregoing, to have and enjoy such powers, and such powers only, as are reasonably necessary and incidental to its operation as a holding corporation, and nothing herein is to be constructed as authorizing the transaction of the bnsiness of a Gas Company.

"*Fourth.*—That the amount of the capital stock of said corporation hereby authorized is $1,500,000, divided into 60,000 shares of the par value of $25 each, which stock shall be divided into classes as follows:

"1. Common stock consisting of 30,000 shares.

"2. Preferred stock consisting of 30,000 shares, the holders of which preferred stock shall be entitled to receive out of the net profits a semi-annual cumulative dividend of 4 per centum, payable on the first days of January and July in each year, beginning on July 1, 1904, which dividends shall be payable before any dividend shall be set apart or paid on the common stock; and for the purpose of determining such preference as against the holders of common stock any and all payments on account of the guarantee by any corporation which may hereafter guarantee the payment of such dividends shall be deemed to be payment of or on account of such dividends. The holders of said preferred stock shall, in case of liquidation or dissolution of the corporation, be entitled to be preferred as to the franchise and entire assets of said corporation and to the full value of said franchise and assets.

"*Fifth.*—That said corporation will commence business with a capital stock of $50,000.

"*Sixth.*—That the duration of said corporation is unlimited unless the holders of the outstanding preferred stock by a two-thirds vote of such preferred stock shall vote to wind up and dissolve the same, either or both, in accordance with the right hereinafter conferred upon such holders of the preferred stock, in which event the duration of said corporation shall be limited accordingly.

"*Seventh.*—That each share of stock, whether preferred or common, shall entitle the holder of record thereof to one vote; except that if this corporation shall fail to pay in full any semi-annual dividend of 4 per centum on its preferred stock, and further if such corporation as shall hereafter guarantee such payment shall fail to pay to the holders of record of such preferred stock or to this corporation in their behalf a sum equal to the amount of the deficiency, and if such default on the part of this corporation and such guarantor shall continue for 60 days, then and in that event this corporation may be wound up and dissolved, either or both, upon a two-thirds vote of the preferred stock issued and outstanding. But nothing herein contained shall be construed as preventing the dissolution of this corporation in accordance with the laws of the State of Connecticut, but the provisions hereof shall be deemed to be in addition thereto.

"*Eighth.*—That no shares of the capital stock of this corporation shall ever be issued, except for shares of the capital stock of the Hartford City Gas Light Company, and such issue shall be only at the rate of one share of the preferred stock and one share of the common stock of this corporation for one share of the capital stock of said the Hartford City Gas Light Company, and not otherwise.

"*Ninth.*—That this corporation shall not by its voluntary act incur any indebtedness of any kind whatsoever, actual or contingent, except for or on account of the expenses properly incident to its operation as a holding company.

"*Tenth.*—That this corporation shall not sell, pledge or otherwise dispose of any of the shares of said the Hartford City Gas Light Company and shall not assign or transfer such shares or any of them, either absolutely or as collateral, except upon the dissolution or winding up of this corporation or except upon a two-thirds vote of all the outstanding stock of each class at a meeting duly called and held for such purpose.

"*Eleventh.*—That the power of this corporation as a holder of shares of the stock of the Hartford City Gas Light Company to vote shall not be exercised upon any proposition to increase the capital stock of said the Hartford City Gas Light Company, except upon a two-thirds vote of all the outstanding shares of each class, at a meeting duly warned and held for such purpose.

"*Twelfth.*—That no amendment, change or alteration in this certificate of incorporation shall be made unless approved by a vote of two-thirds of all the outstanding stock of each class at a meeting of the stockholders duly called to consider such amendment, change or alteration, anything in the present or future statutory law notwithstanding."

MR. E. H. YORKE, writing to us from Portland, Me., of recent date, says: To the Editors AMERICAN GAS LIGHT JOURNAL: The writer has devised a consumers' record system which he thinks has so much merit that he feels that some of the fraternity may be glad to get the suggestions. While some large Companies may have a similar system, inquiries of some of these failed to show such a system, hence the writer believes that it will be new to most managers. The system starts with a library or reference card for *each meter*, printed and ruled as below:

Record of Meter. No.....

Maker's Number..... Maker.. .....
Size.....Lt. kind..... Date bought.....

Sent Out.	Brought In.	Date Tested.	Test.	Date Repaired	Repairs Made.	By.
.....	.....	.....	.....	.....	.....	....
.....	.....	.....	.....	.....	.....	....
.....	.....	.....	.....	.....	.....	....

The number on the top line front is for the company's number, which is stamped on a brass plate attached to the meter. The advantages which follow the use of this system are as follows: It prevents meters being lost; it gives the age of the meter; it tells how long the meter has been in use; it furnishes a quick and ready means of getting all desirable information regarding any meter instantly; it shows when the meter was repaired. what the repairs were, and by whom. From the data which it supplies many valuable deductions may be made, which will readily suggest themselves; and not the least of its merits is that a list can be readily prepared at any time of all meters in use which should be brought in and tested.

THE report of the Buffalo (N. Y.) Gas Company for the year ended September 30th last, recently published, showed net profits for 1903 of $341,212, as against $339,137 in 1902. The interest on bonds amounted to $290,250, leaving the surplus for 1903 $50,962, as against $48,887 in 1902. During the year the sales of gas increased 3.55 per cent. while the number of meters in use increased 3.85. A net gain of 783 gas cooking stoves and other fuel appliances used was made. During the year $30,165.80 was spent for extension of the plant of the Company. It is stated that a more favorable result would have been obtained had it not been for the increased cost of coal and oil.

WE understand that an agreement has been reached by the authorities of Jeffersonville, Ind., and the United Gas and Electric Company under which the latter will charge not to exceed $1 per 1,000 cubic feet for gas, and will maintain 110 arc lamps on public account in consideration of an annual payment of $60 each. The franchise is to run for 50 years.

(*Continued on page* 14.)

THE AMERICAN GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

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NOTIFICATION RESPECTING ADVERTISING.
Orders for new advertising, or for changes in standing advertisements, to insure attention in the issue following their reception, must be in hand any time of Wednesday.

AGENTS:
New York—American News Co., 39 and 41 Chambers St.
Germany—Lemcke & Buechner, of New York.
England—Aug. Siegle, 30 Lime Street, London.

MONDAY, JANUARY 4, 1904.

(*Concluded from page* 13.)

WE understand that a controlling interest in the Stoughton (Mass.) Gas and Electric Light Company has passed into the hands of Messrs. George A. Fernald & Company, of Boston. Mr. Caleb Swan has retired from the management of the concern.

MR. A. G. BRIGGS, formerly of Alameda, Cal., has been appointed Superintendent of the Merced Falls (Cal.) Gas and Electric Company.

SPARTA (Wis.) proposes to have a gas plant, and is about ready to invite proposals on such account.

A CORRESPONDENT forwards the following from Quincy, Ills., under date of December 23d: "Another change was made yesterday morning in the management of the Quincy Gas and Electric Company, when the business of the office, which has been in charge of Thomas F. Clohesey was turned over to C. H. Graf, of Detroit, Mich. Mr. Graf will remain only temporarily, or until his permanent successor has been chosen, which it is expected will be about January 1. The change in the local office was brought about by the transfer of a controlling interest of stock in the Company from J. T. Lynn, of Detroit, Mich., to the Maine syndicate which formerly held this interest in the local plant. The change resulted after a conference of about 3 hours, in which were represented Mr. Lynn's interest in person, and the Maine syndicate by George Macomber, and ex-Governor J. F. Hill, of Augusta, Me.; Mr. Wallace, of Rochester, N. Y., and William B. McKinley, of Champaign, Ills., the Western General Manager of the Maine syndicate. The officers of the Company remain just as they formerly existed, Manchester Haynes being the President, and George E. Macomber, of Augusta, Me., Secretary-Treasurer. The transfer of stock by which the management of the local plant came under the direction of Mr. Lynn, was made last April when the local office was placed in charge of J. C. Sloan, of Port Huron, Mich. On September 1, he was succeeded by Thomas F. Clohesey, who has since been in charge of the lighting and steam heating plants. The plant and system of the Quincy Horse Railway and Carrying Company, is owned by the same syndicate now in possession of the plant of the Quincy Gas and Electric Company. There was no change in ownership of the properties last April, except that the management of the lighting plant was merely divorced from the other. The change effected yesterday practically resumes the former condition."

The Market for Gas Securities.

There was much animation in the city gas share market this week, and values were more than maintained in Consolidated until the close of the week, when a shrinkage of about 3 points in it from the high record was made. The closing to-day (Thursday) was at 194½. There was a good demand for city gas bonds. On Tuesday a sale of 50 shares of Mutual was reported, the price paid being 290. It was knocked down on a single bid.

Brooklyn Union Gas sold up to 218 and a fraction, and then sagged off three points. At the meeting of last Wednesday the shareholders ratified the proposition of the Directors for an increase in the Company's indebtedness, the details of which have heretofore been given in the JOURNAL. The gain in output of the Brooklyn Union concern is surprising even the ideas of its managers. Peoples, of Chicago, is steady, and no change is reported in Baltimore Consolidated. The general market for gas bonds is active, and most of the transactions have been made in the staple issues at about record prices. United Gas Improvement Company's shares are on the strong list, as they undoubtedly should be.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

JANUARY 4.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$73,177,000	100	193¾	194⅛
Central Union, Bonds, 5's.	3,000,000	1,000	104	106
Equitable Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	118	120
Metropolitan	658,000	..	108	112
Mutual	3,500,000	100	290	300
Municipal Bonds	750,000	..	..	..
New Amsterdam Gas Co.. Bonds, 5's	11,000,000	1,000	103	105
Northern Union, Bonds, 5's.	1,250,000	1,000	105	106⅛
New York and East River Bonds 1st 5's	3,500,000	1,000	102	106
" 1st Con. 5's	1,500,000	..	109	111
Standard	5,000,000	100	135	140
Preferred	5,000,000	100	155	170
Bonds, 1st Mortgage, 5's	1,500,000	1,000	116	117
Yonkers	299,680	500	130	..
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	215	..
" " Bonds (5's)	15 000,000	1,000	113	115
Bay State	50,000,000	50	⅛	3/16
" Income Bonds	2,000,000	1,000	..	75
Binghamton Gas Works	450,000	100	28	30
" 1st Mtg. 5's	500,000	1,000	93	96
Boston United Gas Co.— 1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	6¼	8
" " Bonds, 5's	5,250,000	1,000	73	76
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Cincinnati Gas & Elec. Co..	29,500,000	100	97½	98
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	101	101½
Columbus (O.) Gas Lt. & Heating Co	1,682,750	100	88¾	89¼
Preferred	3,026,500	100	107⅞	109
Consumers, Jersey City Bonds	600,000	1,000	100	103
Consumers, Toronto	1,700,000	50	218	225
Consolidated, Baltimore	11,000,000	100	..	59½
Mortgage, 6's	3,600,000	..	..	118
Chesapeake, 1st 6's.	1,000,000	..	..	..
Equitable, 1st 6's.	910,000	..	..	..
Consolidated, 1st 5's	1,490 000	..	..	112
Consolidated Gas Co. of N.J.	1,000,000	100	15	17
" Con. Mtg. 5's	880,000	1,000	86	90
Consolidated G. & E. Co.'s. Little Falls, N.Y.	90,000	100	..	100
Bonds	75,000	..	..	100
Detroit City Gas Co	4,825,500	50	..	50
" Prior Lien 5's	5,603,000	1,000	99¼	100
Detroit Gas Co., 5's	981,000	1,000	75	75¼
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	39	40
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	85	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104½	105
Hartford	750,000	25	245	265
Hudson County Gas Co., of New Jersey	10,500,000	..	25	..
" Bonds, 5's	10,500,000	..	101	103
Indianapolis	2,000,000	..	50	65
" Bonds, 6's	2,650,000	..	103½	106½
Jackson Gas Co	250,000	50	73	75
" 1st Mtg. 5's	290,000	1,000	101	102½
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,822,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	79	90
Preferred	2,500,000	100	..	101
Bonds	10,000,000	1,000	109½	110
Lafayette Gas Co., Ind.	1,000,000	100	..	60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	136	140
Madison Gas & Elec. Co. " 1st Mtg. 6's	350,000	1,000	107½	108½
" 6 per cent. scrip, due 1910	100,000	25	85	87
Montreal, Canada	2,000,000	100	216	184¾
Nashville Gas Lt. Co.	1,000,000	100	110	..
Newark, N. J., Con. Gas Co.	6,000,000	..	56	58
Bonds, 6's	4,600,000	..	105	108¾
New Haven	1,000,000	25	220	..
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	98	98⅛
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,000	1,000	..	..
2d "	2,500,000	1,000	104	..
Rochester Gas & Elec. Co..	2,150,000	50	88	..
Preferred	2,150,000	50	118	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	15,800,000	100	67	67¼
St. Joseph Gas Co. " 1st Mtg. 5's	751,000	1,000	92	96½
St. Paul Gas Light Co	1,500,000	100	45	47
1st Mortgage 6's	650,000	1,000	113	116
Extension, 6's	600,000	1,000	113½	115
General Mortgage, 5's	2,465,000	1,000	92	93
Syracuse, N. Y.	1,975,000	100	46	48
Bonds	2,047,000	1,000	94	96
Washington, D. C	2,600,000	20	280	287½
First mortgage 6's	600,000	..	..	..
Western, Milwaukee	4,000,000	.	..	..
Wilmington, Del.	600,000	50	232	..

Advertisers' Index.

GAS ENGINEERS.	Page
A. E. Boardman, New York City	32
Baxter & Young, Detroit, Mich	32
B. E. Chollar, St. Louis, Mo	18
David Leavitt Hough, New York City	32
Economical Gas Apparatus Construct'n Co., Toronto, Ont.	24
Frank D. Moses, Trenton, N. J	18
Fred. Bredel Co., Milwaukee, Wis	20
Frederic Egner, Washington, D. C	16
Geo. R. Rowland, New York City	22
Humphreys & Glasgow, New York City	33
Kerr Murray Mfg. Co., Fort Wayne, Ind	32
The Gas Machinery Co., Cleveland, O	19
The Jeffrey Manufacturing Co., Columbus, O	30
The Western Gas Construction Co., Fort Wayne, Ind	1040
United Gas Improvement Co., Philadelphia, Pa	27
Wm. Henry White, New York City	35

GAS WORKS APPARATUS AND CONSTRUCTION.

A. E. Boardman, New York City ... 32
Bartlett, Hayward & Co., Baltimore, Md ... 34
Baxter & Young, Detroit, Mich ... 32
Christopher Cunningham, Brooklyn, N.Y ... 29
Connelly Iron Sponge and Governor Co., New York City 1023
Continental Iron Works, Brooklyn, N. Y ... 34
Cruse-Kemper Co., Philadelphia, Pa ... 19
Davis and Farnum Mfg. Co., Waltham, Mass ... 32
Deily & Fowler, Philadelphia, Pa ... 36
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
Frank D. Moses, Trenton, N. J ... 18
Fred. Bredel Co., Milwaukee, Wis ... 20
G. Shepard Page's Sons, New York City ... 32
Humphreys & Glasgow, New York City ... 33
Isbell-Porter Company, New York City ... 34
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 32
Lloyd Construction Co., Detroit, Mich ... 22
Logan Iron Works, Brooklyn, N. Y ... 36
Quintard Iron Works, New York City ... 33
R. D. Wood & Co., Philadelphia, Pa ... 34
Riter-Conley Mfg. Co., Pittsburg, Pa ... 35
Stacey Mfg. Co., Cincinnati, O ... 35
The Connersville Blower Company, Connersville, Ind ... 37
The Gas Machinery Co., Cleveland, O ... 19
The Jeffrey Manufacturing Co., Columbus, O ... 30
The Western Gas Construction Co., Fort Wayne, Ind ... 1040
United Gas Improvement Co., Philadelphia, Pa ... 27

PROCESSES.

Bartlett, Hayward & Co., Baltimore, Md ... 33
B. E. Chollar, St. Louis, Mo ... 18
Economical Gas Apparatus Construct'n Co, Toronto, Ont. 24
Humphreys & Glasgow, New York City ... 33
The Gas Machinery Co., Cleveland, O ... 19
The Western Gas Construction Co., Fort Wayne, Ind ... 1040
United Gas Improvement Co., Philadelphia, Pa ... 27

SCRUBBERS AND CONDENSERS.

Continental Iron Works, Brooklyn, N.Y ... 34
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 32
Logan Iron Works, Brooklyn, N. Y ... 36
R. D. Wood & Co., Philadelphia, Pa ... 34
Riter-Conley Mfg. Co., Pittsburg, Pa ... 35
Stacey Mfg. Co., Cincinnati, O ... 35
The Gas Machinery Co., Cleveland, O ... 19
The Western Gas Construction Co., Fort Wayne, Ind ... 1040

PRODUCER POWER PLANTS.

Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
R. D. Wood & Co., Philadelphia, Pa ... 34

TAR AND CARBONIC ACID EXTRACTOR.

Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
Stacey Mfg. Co., Cincinnati, O ... 35
The Gas Machinery Co., Cleveland, O ... 19
The Western Gas Construction Co., Fort Wayne, Ind ... 1040

AMMONIA CONCENTRATORS.

Michigan Ammonia Works, Detroit, Mich ... 20
The Gas Machinery Co., Cleveland, O ... 19
The Western Gas Construction Co., Fort Wayne, Ind ... 1040

GAS METERS.

American Meter Co., New York and Philadelphia ... 39
Detroit Meter Company, Detroit, Mich ... 1039
D. McDonald & Co., Albany, N.Y ... 37
Helme & McIlhenny, Philadelphia, Pa ... 39
John J. Griffin & Co., Philadelphia, Pa ... 40
Keystone Meter Co., Royersford, Pa ... 38
Maryland Meter and Mfg. Co., Baltimore, Md ... 38
Metric Metal Co., Erie, Pa ... 39
Nathaniel Tufts Meter Co., Boston, Mass ... 38

PREPAYMENT METERS.

American Meter Co., New York and Philadelphia ... 39
D. McDonald & Co., Albany, N. Y ... 37
Helme & McIlhenny, Philadelphia, Pa ... 39
John J. Griffin & Co., Philadelphia, Pa ... 40
Keystone Meter Co., Royersford, Pa ... 38
Nathaniel Tufts Meter Co., Boston, Mass ... 38

PREPAYMENT METER ATTACHMENTS.

Reeves Mfg. Co., New Haven, Conn ... 20

GAS AND WATER PIPES.

Christopher Cunningham, Brooklyn, N.Y ... 29
Davis & Farnum Mfg. Co., Waltham, Mass ... 32
Donaldson Iron Co., Emaus, Pa ... 24
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
M. J. Drummond & Co., New York City ... 24
R. D. Wood & Co., Philadelphia, Pa ... 34
Warren Foundry and Machine Co., New York City ... 24

NON-RUSTING PIPE LUBRICANT.

Alan H. Tripp, Chicago, Ills ... 20

GAS COALS.

Berwind-White Coal Mining Co., New York and Phila. 30
Perkins & Co., New York City ... 30
Westmoreland Coal Co., Philadelphia, Pa ... 31

SPECIALTIES FOR OIL AND PIPE LINES.

S. R. Dresser, Bradford, Pa ... 21

GAS MAIN STOPPERS.

Safety Gas Main Stopper Co., N.Y. City ... 24

GAS TAPPING MACHINES.

George Light, Dayton, O ... 24
H. Mueller Manufacturing Company, Decatur, Ills ... 21

CANNEL COALS.

Perkins & Co., New York City ... 30

STOKING MACHINERY.

G. A. Bronder, New York City ... 29

AUTOMATIC WEIGHING MACHINERY.

Richardson Scale Co., New York City ... 20

CONVEYORS.

C. W. Hunt Company, New York City ... 21
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
G. A. Bronder, New York City ... 29
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 32
The Gas Machinery Co., Cleveland, O ... 19
The Jeffrey Manufacturing Co., Columbus, O ... 30
The Link-Belt Machinery Co., Chicago, Ills ... 16
The Western Gas Construction Co., Fort Wayne, Ind ... 1040

CHARGING BARROWS & COAL WAGONS.

Kerr Murray Mfg. Co., Fort Wayne, Ind ... 32
Stacey Mfg. Co., Cincinnati, O ... 35

GAS ENRICHERS.

Standard Oil Co., New York City ... 1031
Sun Company, Pittsburg, Pa ... 31
The Sun Oil Co., Pittsburg, Pa ... 31

COKE CRUSHERS.

C. M. Keller, Columbus, Ind ... 31
The Jeffrey Manufacturing Co., Columbus, O ... 30

STEAM BLOWER FOR BURNING BREEZE.

The Connersville Blower Company, Connersville, Ind ... 37

ECONOMIZERS.

Green Fuel Economizer Co., Matteawan, N.Y ... 22

GAS GAUGES.

The Bristol Co., Waterbury, Conn ... 22

GAS GOVERNORS.

Connelly Iron Sponge and Governor Co., New York City 1023
Isbell-Porter Co., New York City ... 34
R. D. Wood & Co., Philadelphia, Pa ... 34

CEMENTS.

C. L. Gerould, Galesburg, Ills ... 28

RETORTS AND FIREBRICKS.

Adam Weber Sons, New York City ... 28
Baltimore Retort and Firebrick Co., Baltimore, Md ... 28
Brooklyn Firebrick Works, Brooklyn, N. Y ... 28
Henry Maurer & Son, New York City ... 24
James Gardner, Jr., Co., Pittsburg, Pa ... 28
J. H. Gautier & Co., Jersey City, N. J ... 28
Laclede Firebrick Mfg. Co., St. Louis, Mo ... 28
Missouri Firebrick Co., St. Louis, Mo ... 28
Parker-Russell Mining and Mfg. Co., St. Louis, Mo ... 18
The Kreischer Brick Mfg. Co., New York City ... 28

INCLINED RETORTS.

Adam Weber Sons (Graham, Morton [England] System) 28
Connelly Iron Sponge & Gov. Co. (Drake's [Eng.] System) 1023
Parker-Russell Mining and Mfg. Co., St. Louis, Mo ... 18

VERTICAL S'S.

Adam Weber Sons (Oscar B. Weber's Construction) ... 28
Connelly Iron Sponge & Gov. Co. (Drake's [Eng.] System) 1023
Parker-Russell Mining and Mfg. Co., St. Louis, Mo ... 18

REGENERATIVE FURNACES.

Adam Weber Sons, New York City ... 28
Bartlett, Hayward & Co., Baltimore, Md ... 33
Fred. Bredel Co., Milwaukee, Wis ... 20
J. H. Gautier & Co., Jersey City, N.J ... 28
Laclede Firebrick Mfg. Co., St. Louis, Mo ... 28
Missouri Firebrick Co., St. Louis, Mo ... 28
Parker-Russell Mining and Mfg. Co., St. Louis, Mo ... 18

SELF-SEALING MOUTHPIECE DOORS.

Continental Iron Works, Brooklyn, N.Y ... 34
Isbell-Porter Co., New York City ... 34
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 32
Logan Iron Works, Brooklyn, N.Y ... 36
R. D. Wood & Co., Philadelphia, Pa ... 34
Stacey Mfg. Co., Cincinnati, O ... 35
The Gas Machinery Co., Cleveland, O ... 19
The Western Gas Construction Co., Fort Wayne, Ind ... 1040

CHIMNEY CONSTRUCTION.

Adam Weber Sons, New York City ... 28

INCANDESCENT GAS LAMPS.

Ball Check Light Co., New York City ... 18
D. M. Steward Mfg. Co., Chattanooga, Tenn ... 20
General Gas Light Co., Kalamazoo, Mich ... 19
Lindsay & Co., Chicago, Ills ... 17
Welsbach Company, Gloucester, N. J ... 20

BURNERS.

D. M. Steward Mfg. Co., Chattanooga, Tenn ... 20
Wm. M. Crane Co., New York City ... 21

LAVA GAS TIPS.

D. M. Steward Mfg. Co., Chattanooga, Tenn ... 20

STREET LAMPS.

Thos. T. W. Miner, New York City ... 21
Welsbach Street Lighting Co., New York and Phila ... 26

(*Continued on page* 16.)

DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO., N. W. CORNER BROAD AND ARCH STS., PHILADELPHIA, PA., Dec. 9, 1903.

The Directors have this day declared a quarterly dividend of 2 per cent. (one dollar per share), payable Jan. 15th, 1904, to stockholders of record at the close of business, Dec. 31, 1903. Checks will be mailed.

1488-5 LEWIS LILLIE, Treasurer.

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GAS ENGINEER,

Energetic and fully acquainted with modern systems of making coal gas, horizontal as well as inclined, is open for engagement. Can construct, build and operate works, with guarantee of highest and best results. Address,

1490-3 "PROGRESS," care this Journal.

SITUATION WANTED

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By a man 44 years old. Has made good showing in developing new business. Is at present with plant putting out 350,000,000 yearly. Address, "A. B.,"

1484-tf Care this Journal.

Position Wanted

AS ASSISTANT SUPERINTENDENT OR FOREMAN,

By a man 29 years of age; college graduate; thoroughly familiar with manufacturing coal and water gas; construction of benches and apparatus. At present employed in a coal and water gas plant, having an annual output of 1,000,000,000 cubic feet. First-class references. Address,

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Experienced Man Wants Position as Manager or Superintendent of Coal Gas Property.

Single man, 30 years of age, with 10 years' experience and first-class references. Address, "COAL GAS,"

1489-tf Care this Journal.

Wanted Position.

Having disposed of my interest in the works I am now managing, would like a position with some gas and electric light company as manager. Have never made a failure of any works I have managed.

1490-tf Address, "W. T.," care this Journal.

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To take full charge of business, or superintendent of manufacturing, distribution and soliciting for new business. Prefers town where business needs working up through the proper pushing of gas arcs, gas stoves and other gas appliances. Will be open for an engagement Jan. 1. First-class references as to ability, character and responsibility.

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FOR SALE.

One Set of Lowe System Water Gas Apparatus.

Second-hand. For details write to the

DOVER GAS LIGHT COMPANY,
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(*Continued from page* 15.)

PURIFIERS.

Connelly Iron Sponge and Governor Co., New York City. 23
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 32
R. D. Wood & Co., Philadelphia, Pa 34
Stacey Mfg. Co., Cincinnati, O..... 35
The Western Gas Construction Co., Fort Wayne, Ind...1040

PURIFYING MATERIALS.

Connelly Iron Sponge and Governor Co., New York City 1023

VALVES.

Continental Iron Works, Brooklyn, N. Y..... 34
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
Isbell-Porter Co., New York City..... 34
Kerr Murray Mfg. Co., Fort Wayne, Ind 32
Ludlow Valve Manufacturing Co., Troy, N.Y..... 21
R. D. Wood & Co., Philadelphia, Pa..... 34
Stacey Mfg. Co., Cincinnati, O..... 35
The P. H. & F. M. Roots Co., Connersville, Ind..... 23
The Western Gas Construction Co., Fort Wayne, Ind... 1040

EXHAUSTERS.

Connelly Iron Sponge and Governor Co., New York City 1023
Isbell-Porter Company, New York City..... 34
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 32
The Connersville Blower Company, Connersville, Ind... 33
The P. H. & F. M. Roots Co., Connersville, Ind..... 23

ELECTRICAL APPARATUS.

Wm. Henry White, New York City..... 35

PURIFIER SCREENS.

John Cabot, Hoboken, N. J..... 20

GAS STOVES.

Abendroth Brothers, New York City..... 16
American Meter Co., New York and Philadelphia..... 25
Detroit Stove Works, Detroit and Chicago..... 16
Keystone Meter Co., Royersford, Pa..... 38
Maryland Meter and Manufacturing Co., Baltimore, Md. 38
Nathaniel Tufts Meter Co., Boston, Mass..... 38

HOT WATER HEATERS.

Abendroth Brothers, New York City..... 16
The Humphrey Mfg. and Plating Co., Kalamazoo, Mich. 24

GASHOLDER TANKS.

J. P. Whittier, Brooklyn, N.Y..... 22

GASHOLDERS.

Bartlett, Hayward & Co., Baltimore, Md..... 33
Continental Iron Works, Brooklyn, N.Y..... 34
Cruse-Kemper Co., Philadelphia, Pa..... 19
Davis & Farnum Mfg. Co., Waltham, Mass..... 32
Deily & Fowler, Philadelphia, Pa..... 36
Economical Gas Apparatus Construct'n Co., Toronto, Ont. 24
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 32
Logan Iron Works, Brooklyn, N Y..... 36
R. D. Wood & Co., Philadelphia, Pa..... 34
Riter-Conley Mfg. Co., Pittsburg, Pa..... 35
Stacey Mfg. Co., Cincinnati, O..... 35

STORAGE TANKS.

Christopher Cunningham, Brooklyn, N.Y..... 29
Stacey Mfg. Co., Cincinnati, O..... 35

PAINTS.

National Paint Works, New York City..... 32

AUTOMATIC SCALES.

Richardson Scale Co., New York City..... 20

INVESTORS.

W. R. Faben Construction Company, Toledo, O..... 30

PATENTS, TRADE-MARKS, COPYRIGHTS.

Royal E. Burnham, Washington, D. C..... 20

BOOKS, ETC.

Self-Instruction for Students in Gas Manufacture 21
Finances of Gas and Electricity Mfg. Enterprises 21
Practical Handbook on Gas Engines..... 29
Hughes' "Gas Works"..... 30
Electric Gas Lighting..... 30
Coal Tar and Ammonia..... 30
Gas Analyst's Manual 36
Field's Analysis, 1902..... 38
Gas Flow Computers..... 31
Excerpts from Reports of Gas Commissioners..... 39
Directory of Gas Companies..... 35
Gas Engineer's Laboratory Handbook..... 34
Gas Engineer's Pocket-Book..... 28
Poole on Fuels..... 31
Binders..... 31

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OFFICE OF

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Gen. Mgr.

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They Sell For
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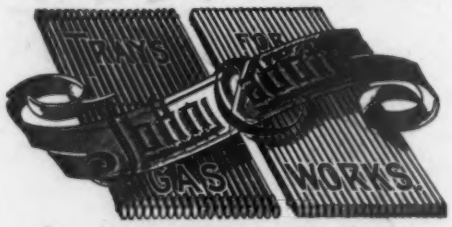

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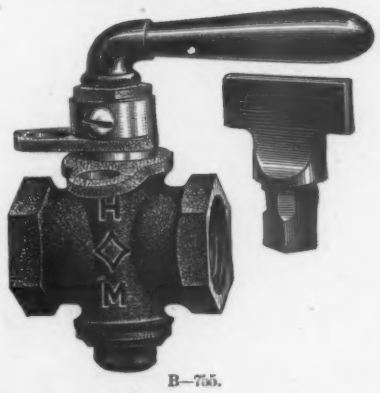

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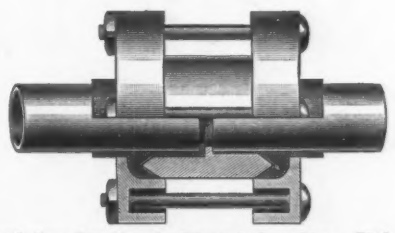

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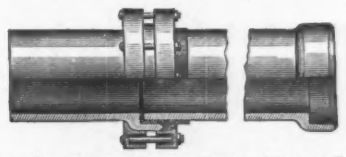

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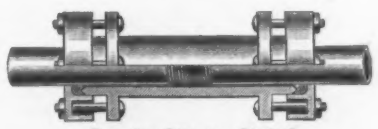

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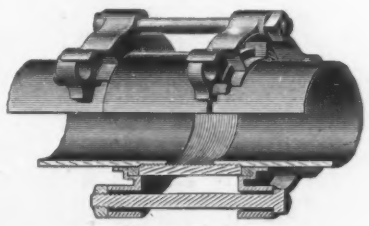

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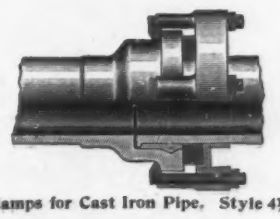

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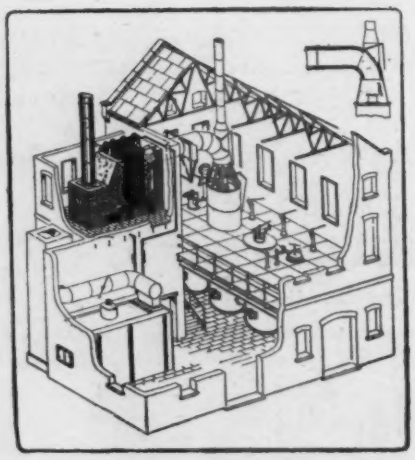

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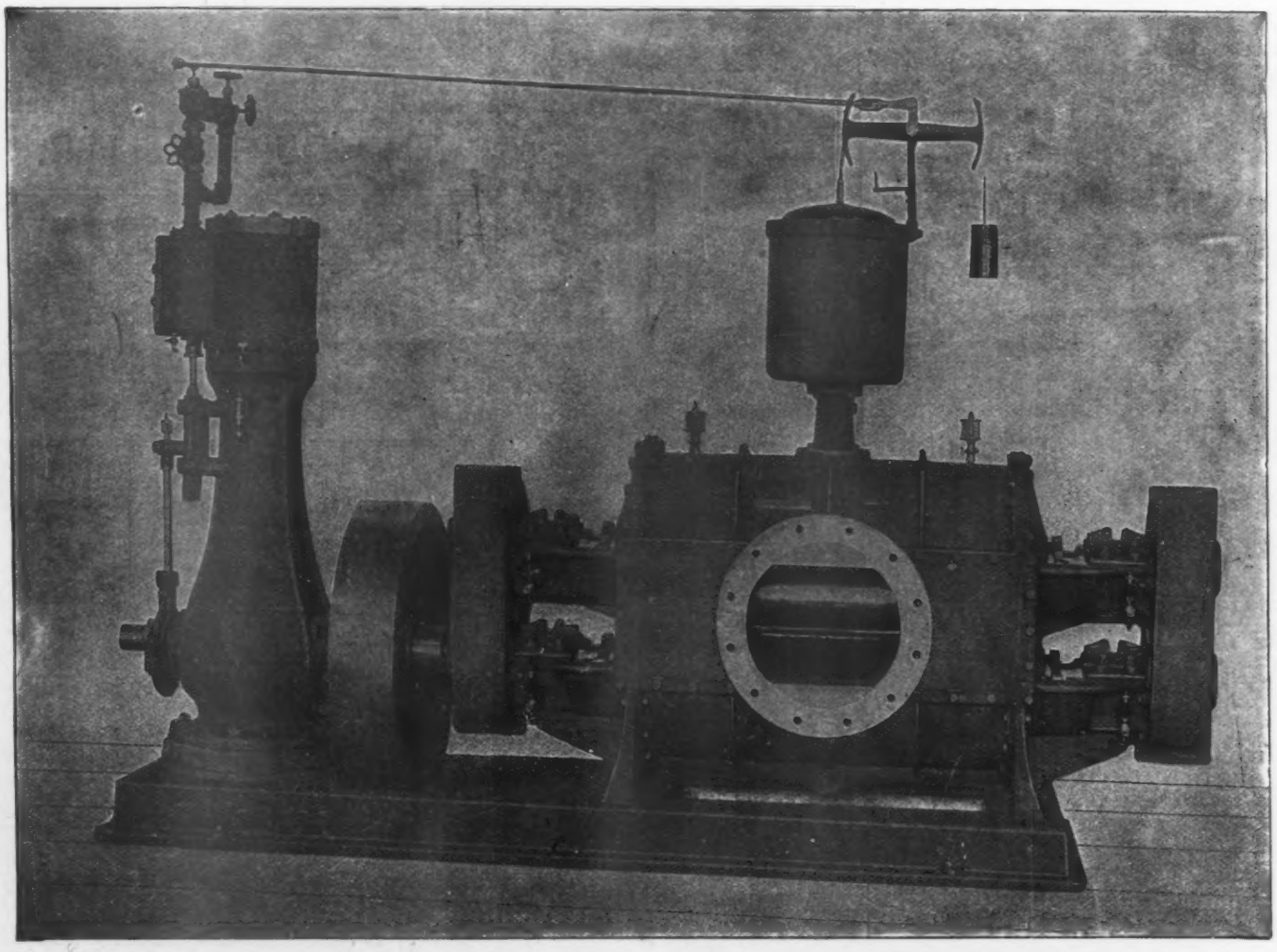

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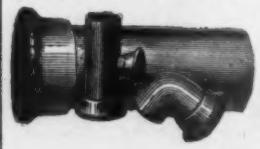

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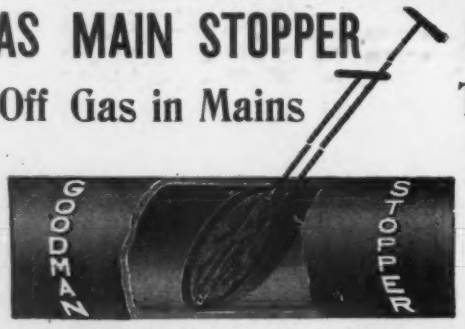

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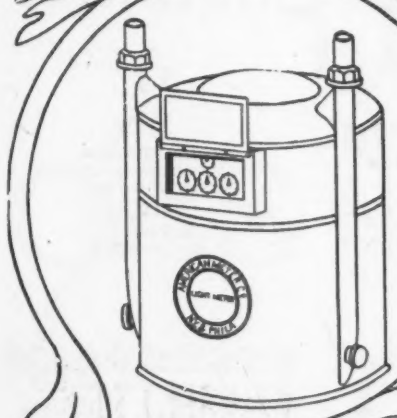
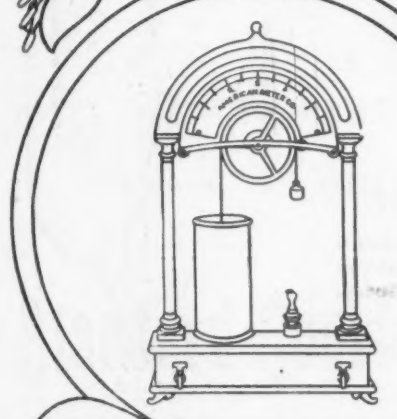
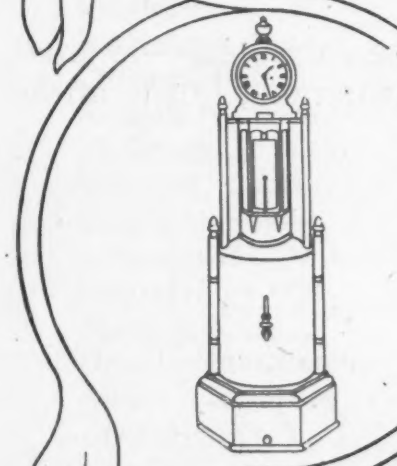
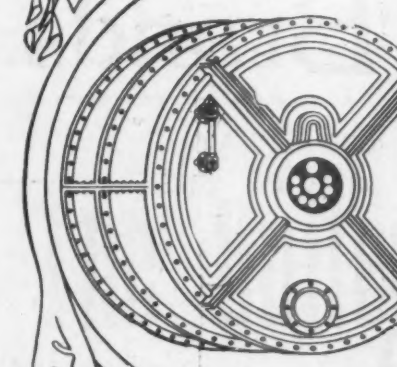








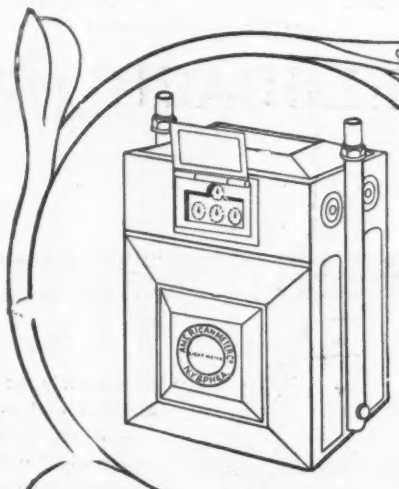
PUBLIC LIGHTING TABLE.

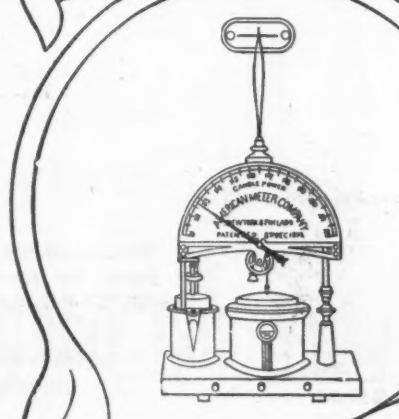
JANUARY, 1904.

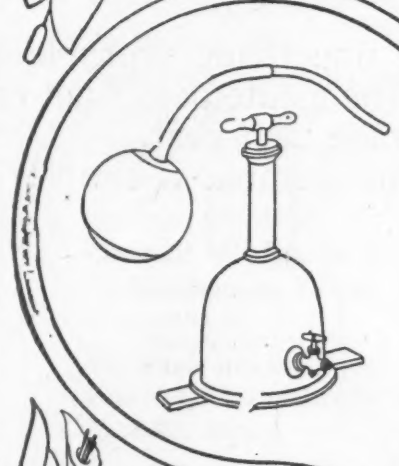
Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Fri.	1	No L.	No L.	4.30	6.30
Sat.	2	No L. FM	No L.	4.30	6.30
Sun.	3	No L.	No L.	4.30	6.30
Mon.	4	5.20 PM	7.50 PM	4.30	6.30
Tue.	5	5.20	9.00	4.30	6.30
Wed.	6	5.20	10.20	4.30	6.30
Thu.	7	5.20	11.30	4.30	6.30
Fri.	8	5.20	12.30 AM	4.40	6.30
Sat.	9	5.20 LQ	1.40	4.40	6.30
Sun.	10	5.30	2.40	4.40	6.30
Mon.	11	5.30	3.40	4.40	6.30
Tue.	12	5.30	4.40	4.40	6.30
Wed.	13	5.30	5.30	4.40	6.30
Thu.	14	5.30	6.20	4.40	6.30
Fri.	15	5.30	6.20	4.50	6.25
Sat.	16	5.30	6.20	4.50	6.25
Sun.	17	5.30 NM	6.20	4.50	6.25
Mon.	18	5.30	6.20	4.50	6.25
Tue.	19	5.30	6.20	4.50	6.25
Wed.	20	5.30	6.20	4.50	6.25
Thu.	21	5.30	6.20	4.50	6.25
Fri.	22	9.00	6.20	5.00	6.25
Sat.	23	10.00	6.20	5.00	6.25
Sun.	24	11.00	6.10	5.00	6.25
Mon.	25	11.50 FQ	6.10	5.00	6.25
Tue.	26	1.00 AM	6.10	5.00	6.25
Wed.	27	2.00	6.10	5.00	6.25
Thu.	28	3.00	6.10	5.00	6.25
Fri.	29	4.00	6.10	5.05	6.15
Sat.	30	5.00	6.10	5.05	6.15
Sun.	31	No L.	No L.	5.05	6.15

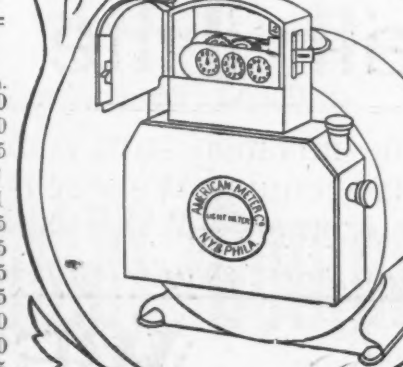
TOTAL HOURS LIGHTING DURING 1904.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	225.00	January	423.20
February	205.40	February	367.40
March	187.40	March	355.35
April	169.50	April	298.50
May	152.30	May	264.50
June	137.20	June	234.25
July	138.50	July	243.45
August	151.00	August	280.25
September	164.40	September	321.15
October	191.30	October	374.30
November	210.30	November	401.40
December	237.10	December	433.45
Total, yr.	2171.40	Total, yr.	4000.00









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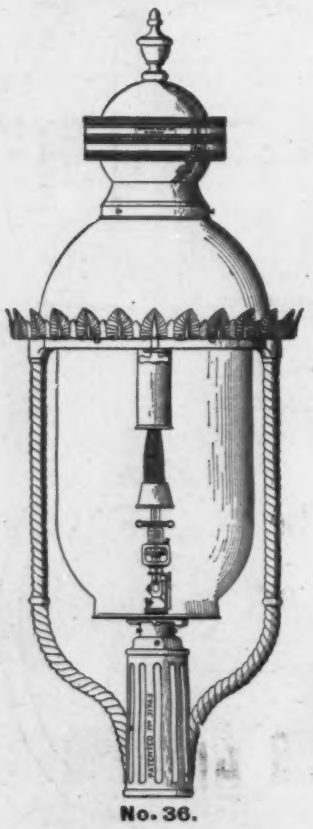

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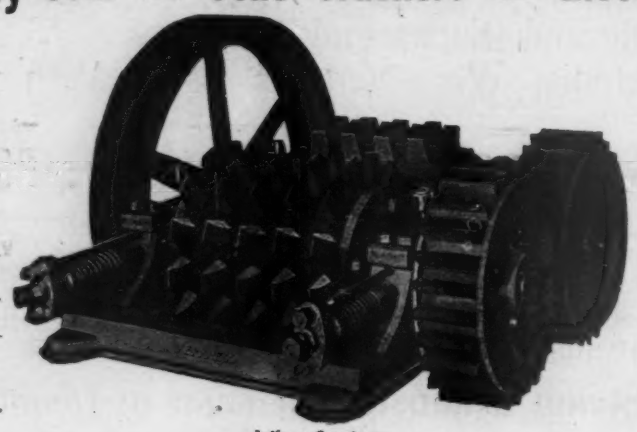

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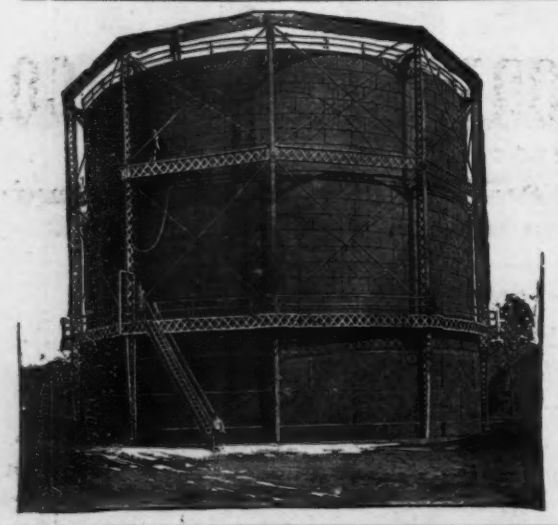

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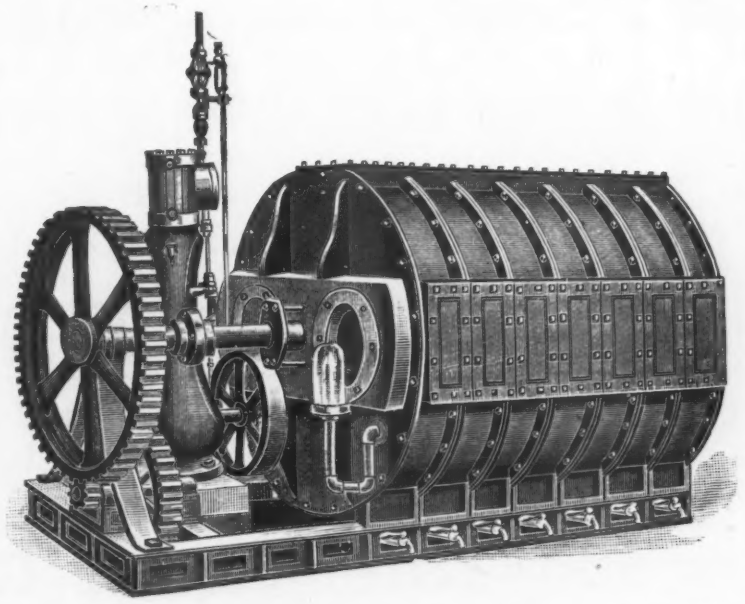

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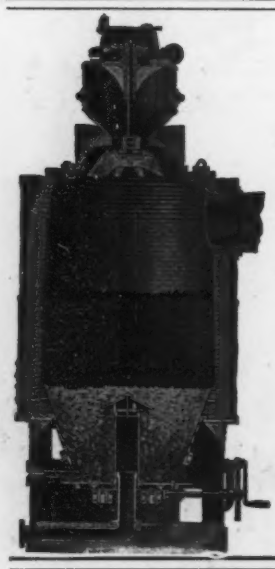

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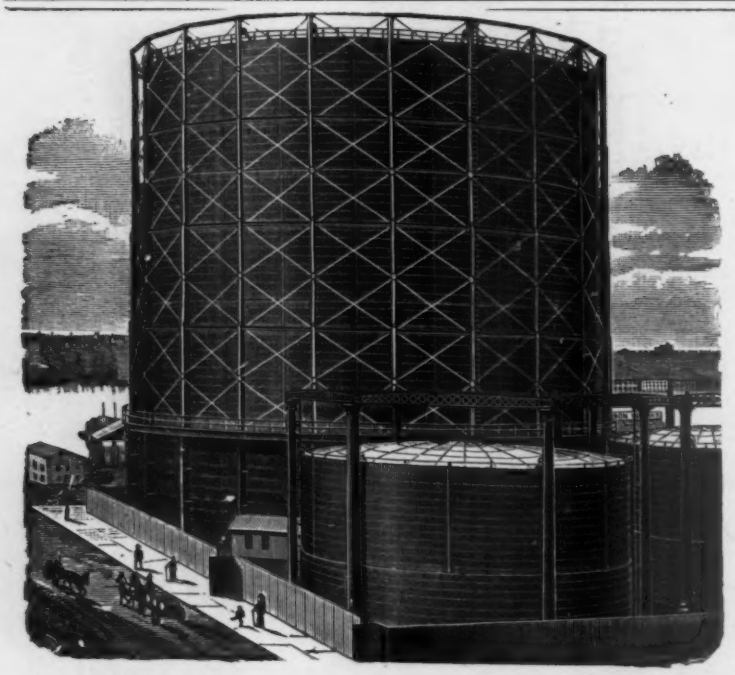

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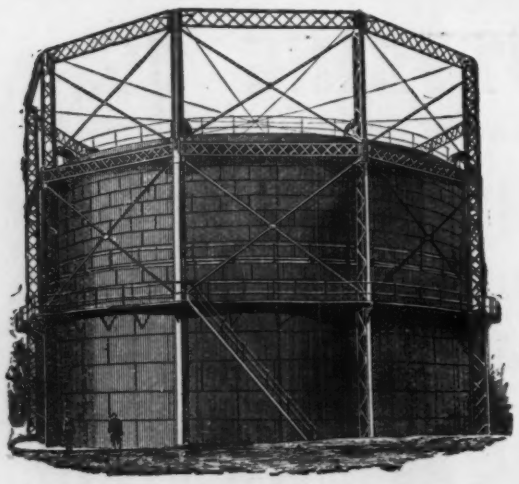

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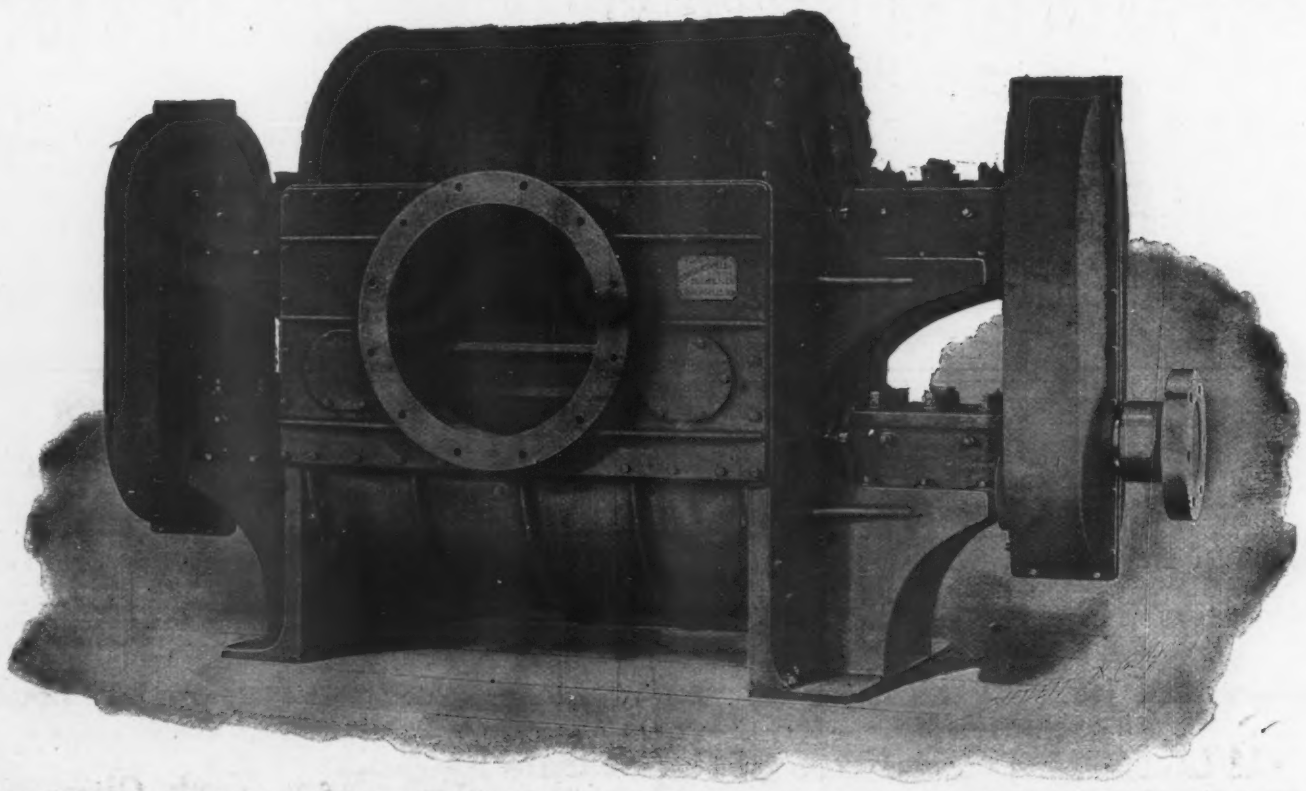

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